THE

AMERICAN NATURALIST.

Vol. IX.—FEBRUARY, 1875.—No. 2.

ON THE CLASSIFICATION OF THE ANIMAL KINGDOM.[1]

BY PROFESSOR T. H. HUXLEY.

Linnæus defines the object of classification as follows:—"Methodus, anima scientiæ, indigitat, primo intuitu, quodcumque corpus, naturale, ut hoc corpus dicat proprium suum nomen, et hoc nomen quæcumque de nominato corpore beneficio seculi innotuere, ut sic in summa confusione rerum apparenti, summus conspiciatur Naturæ ordo." ("Systema Naturæ," ed. 12, p. 13.)

With the same general conception of classificatory method as Linnæus, Cuvier saw the importance of an exhaustive analysis of the adult structure of animals, and his classification is an attempt to enunciate the facts of structure thus determined, in a series of propositions of which the most general constitute the definitions of the largest, and the most special, the definitions of the smallest groups.

Von Baer showed that our knowledge of animal structure is imperfect unless we know the developmental stages through which that structure has passed; and since the publication of his "Entwickelungs-Geschichte der Thiere," no philosophical naturalist has neglected embryological facts in forming a classification.

Darwin, by laying a novel and solid foundation for the theory

[1] Paper read at the Linnean Society, Dec. 4, 1874. Printed from advance proofs corrected by the author.

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of evolution, introduced a new element into taxonomy. If a species, like an individual, is the product of a process of development, its mode of evolution must be taken into account in determining its likeness or unlikeness to other species; and thus "phylogeny" becomes not less important than embryogeny to the taxonomist. But while the logical value of phylogeny must be fully admitted, it is to be recollected that in the present state of science absolutely nothing is positively known respecting the phylogeny of any of the larger groups of animals. Valuable and important as phylogenic speculations are as guides to, and suggestions of, investigation, they are pure hypotheses incapable of any objective test; and there is no little danger of introducing confusion into science by mixing up such hypotheses with taxonomy, which should be a precise and logical arrangement of verifiable facts.

The present essay is an attempt to classify the known facts of animal structure, including the development of that structure, without reference to phylogeny, and, therefore, to form a classification of the animal kingdom which will hold good, however much phylogenic speculations may vary.

Animals are primarily divisible into those in which the body is not differentiated into histogenetic cells (Protozoa), and those in which the body becomes differentiated into such cells (Metazoa of Hæckel).

I. The Protozoa are again divisible into two groups: 1. the Monera (Hæckel), in which the body contains no nucleus; and 2. the Endoplastica, in which the body contains one or more nuclei. Among these the Infusoria, Ciliata and Flagellata (*e.g.*, Noctiluca), while not forsaking the general type of the single cell, attain a considerable complexity of organization, presenting a parallel to what happens among the unicellular Fungi and Algæ (*e.g.*, Mucor, Vaucheria, Caulerpa).

II. The Metazoa are distinguishable, in the first place, into those which develop an alimentary cavity—a process which is accompanied by the differentiation of the body wall into, at fewest, two layers, an epiblast and a hypoblast (*Gastræa* of Hæckel), and those in which no alimentary cavity is ever formed.

Among the Gastræa there are some in which the gastrula, or primitive sac with a double wall open at one end, retains this primitive opening throughout life as the egestive aperture; numerous

ingestive apertures being developed in the lateral walls of the gastrula—whence these may be termed Polystomata. This group comprehends the Spongida or Porifera. All other Gastrææ are Monostomata, that is to say, the gastrula develops but one ingestive aperture. The case of compound organisms in which new gastrulæ are produced by germination is of course not a real exception to this rule.

In some Monostomata the primitive aperture becomes the permanent mouth of the animal (Archæstomata).

This division includes two groups, the members of each of which are very closely allied:—1. The Cœlenterata. 2. The Scolecimorpha. Under the latter head are included the Turbellaria, the Nematoidea, the Trematoda, the Hirudinea, the Oligochæta, and probably the Rotifera and Gephyrea.

In all the other Monostomata the primitive opening of the gastrula, whatever its fate, does not become the mouth, but the latter is produced by a secondary perforation of the body wall. In these Deuterostomata there is a perivisceral cavity distinct from the alimentary canal, but this perivisceral cavity is produced in different ways.

1. A perivisceral cavity is formed by diverticula of the alimentary canal, which become shut off from the latter (Enterocœla).

The researches of Alexander Agassiz and of Metschnikoff have shown that, not only the ambulacral vessels, but the perivisceral cavity of the echinodermata are produced in this manner; a fact which may be interpreted as indicating an affinity with the Cœlenterates (though it must not be forgotten that the dendrocœle Turbellaria and many Trematoda are truly "cœlenterate"), but does not in the least interfere with the fundamental resemblance of these animals to the worms.

Kowalevsky has shown that the perivisceral cavity of the anomalous Sagitta is formed in the same way, and the researches of Metschnikoff appear to indicate that something of the same kind takes place in Balanoglossus.

2. A perivisceral cavity is formed by the splitting of the mesoblast (Schizocœla).

This appears to be the case in all ordinary Mollusca, in all the polychætous Annelida, of which the Mollusca are little more than an oligomerous modification, and in all the Arthropoda.

It remains to be seen whether the Brachiopoda and the Polyzoa belong to this or the preceding division.

3. A perivisceral cavity is formed neither from diverticula of the alimentary canal nor by the splitting of the mesoblast, but by an outgrowth or invagination of the outer wall of the body (Epicæla).

The Tunicata are in this case, the atrial cavity in them being formed by invagination of the epiblast.

Amphioxus, which so closely resembles an Ascidian in its development, has a perivisceral cavity which essentially corresponds with the atrium of the Ascidian, though it is formed in a somewhat different manner. One of the most striking peculiarities in the structure of Amphioxus is the fact that the body wall (which obviously answers to the somatopleure of one of the higher vertebrata, and incloses a "pleuro-peritoneal" cavity in the walls of which the generative organs are developed), covers the branchial apertures, so that the latter open into the "pleuro-peritoneal" cavity. This occurs in no other vertebrated animal. Kowalevsky has proved that this very exceptional structure results from the development of the somatopleure as a lamina which grows out from the sides of the body and eventually becomes united with its fellow in the middle ventral line, leaving only the so-called "respiratory pore" open. Stieda has mentioned the existence of the raphè in the position of the line of union in the adult animal. Rathke described two "abdominal canals" in Amphioxus; and Johannes Müller, and more recently Stieda, have described and figured these canals. However, Rathke's canals have no existence, and what have been taken for them are simply passages, or semi-canals, between the proper ventral wall of the abdomen and the incurved edges of two ridges developed at the junction of the ventral with the lateral faces of the body, which extend from behind the abdominal pore where they nearly meet, to the sides of the mouth. Doubtless the ova which Kowalevsky saw pass out of the mouth, had entered into these semi-canals when they left the body by the abdominal pore, and were conveyed by them to the oral region. The ventral integument between the ventrolateral laminæ is folded as Stieda has indicated, into numerous close-set longitudinal plaits which have been mistaken for muscular fibres, and the grooves between these plaits are occupied by epidermic cells, so that in transverse section the interspaces between the plaits have the appearance of glandular cæca. This plaited organ appears to represent the Wolffian duct of the higher Vertebrata, which, in accordance with the generally embryonic character of

Amphioxus, retains its primitive form. The somatopleure of Amphioxus therefore resembles that of ordinary vertebrata in giving rise to a Wolffian duct by invagination of its inner surface. But the Wolffian duct does not become converted into a tube, and its dorsal or axial wall unites with its fellow in the raphé of the ventral boundary of the perivisceral cavity.

In all the higher Vertebrata of which the development has yet been traced, the "pleuro-peritoneal" or perivisceral cavity arises by an apparent splitting of the mesoblast, which splitting, however, does not extend beyond the hinder portion of the branchial region. But in many vertebrata (*e.g.*, Holocephali, Ganoidei, Teleostei, Amphibia) a process of the integument grows out from the region of the hyoidean arch, and forms an operculum covering the gill-cleft. In the frog, as is well known, this opercular membrane is very large, and unites with the body wall posteriorly, leaving only a "respiratory pore" on the left side, during the later periods of the tadpole's life. Here is a structure homologous with the splanchnopleure of Amphioxus; while, in the thoraco-abdominal region, the splanchnopleure appears to arise by splitting of the mesoblast. Considering what takes place in Amphioxus, the question arises whether the "splitting" of the mesoblast in the Vertebrata may not have a different meaning from the apparently similar process in the Arthropoda, Annelida and Mollusca; and whether the pericardium, pleura, and peritoneum are not parts of the epiblast, as the atrial tunic is of the epiblast of the ascidians. Further investigation must determine this point. In the meanwhile, on the assumption that the "pleuro-peritoneal" cavity of the Vertebrata is a virtual involution of the epiblast, the peritoneal aperture of fishes becomes truly homologous with the "respiratory pore" of Amphioxus; and the Wolffian ducts and their prolongations, with the Müllerian ducts, are, as Gegenbaur has already suggested, of the same nature as the segmental organs of worms.

The division of Metazoa without an alimentary cavity is established provisionally, for the Cestoidea and Acanthocephala, in which no trace of a digestive cavity has ever been detected. It is quite possible that the ordinary view that these are Gastræa modified by parasitism is correct. On the other hand, the cases of the Nematoid worms and of the Trematoda show that the most complete parasitism does not necessarily involve the abortion of the

alimentary cavity, and it must be admitted to be possible that a primitive gregariniform parasite might become multicellular and might develop reproductive and other organs, without finding any advantage in an alimentary canal. A purely objective classification will recognize both these possibilities and leave the question open.

THE SONG OF THE CICADA.

BY F. C. CLARK, M. D.

It must not be considered that all music is a succession of delightful sounds. Harmony, it is true, depends much upon the construction of the musical apparatus, but it depends still more upon the skill of the operator and the taste of the listener. Hence among the lowest insect tribes, many a rough, rasping note, though awakening no particular delight in us, serves as great a purpose as the more pleasant sounds.

On any warm sunny afternoon, or evening, insect courtships take place in countless numbers under our very eyes if we would only use them. What *Katy-did*, which name the insect has borne for ages, still exercises the imagination of poets and philosophers. We hear it loudly whispered in trees and shrubbery, that something was done by "Katy," but beyond that we are left in utter darkness; though some poets have even attempted to unravel the mystery.

Among still higher orders of animals, as our birds, we find the plumage of the male more brilliant, during the pairing season, and their songs more ravishing than before. At this time they charm the human listener, even as much as the delighted female bird. Even our barn-yard cock, good chanticleer, assumes a bolder front, and echoes his joyous notes over hill and dale.

Rising to mammals, man excepted, we shall observe certain sounds more or less pleasant, but still sufficient to fulfil the object for which they were created.

Therefore from the human family, where music reaches its highest perfection, down to the lowest and meanest insect that utters a sound, each furnishes notes to form the grand harmony of nature, in the great struggle for existence. To a cultivated

ear, the peep of a frog, or the chirp of a cricket, is not less unpleasing than the monotonous humdrum of the savage, who represents now the place formerly occupied by the most cultivated nations of the world.

The cicada (or harvest-fly), improperly called "locust," is so familiar that its description seems hardly necessary. Suffice it to say, that from the middle of June to early autumn, this joyous little songster is heard piping away upon the trees.

The insects especially known to us are the trumpeter (*Cicada tibicen*) or lyreman, as it is known in Surinam, from its noise resembling the notes of a lyre, and the red-eyed cicada, or seventeen-year locust (*C. septendecim*). There is a third (*C. canicularis*) which appears during dog-days only. Its inferior aspect is covered with a substance resembling meal.

The lyreman comes to us in a garb of green, and with wings trimmed with the same color. The red-eyed cicada is clothed in red as the lyreman is in green. This last insect has been thought only to appear as its name indicates. But though less numerous than the trumpeter, the red-eyed locusts may be found during every year, though in different regions of our country, its name to the contrary notwithstanding.

But it is the cicada's song, which chiefly interests us now—its "noise" if you will have it so. In some countries where the harvest-fly abounds (for all species of it sing in the same way) its stridulent noise is in some instances almost deafening, and may be heard a mile off. But our cicada, I am happy to say, is not so annoying.

The males alone are provided with the musical apparatus. This fact led a very satirical Greek, Zenarchos by name, to exclaim, I fear, not in a very gallant manner:

> "Are not cicadas truly blest
> By not a female voice oppressed."

The ancients speak of them in the most flattering terms. So much did they please our Greek and Roman friends, that they were kept in cages, as one would pet a bird.

The Athenian ladies wore gold cicadas in their hair as ornaments. A toy cicada, sitting upon a harp, was an emblem of the science of music.

But the cicada was not alone beloved for its song. They were also served up as dainty morsels to Athenian epicures. A shrewd

old philosopher remarked, that cicadas were good in the pupa state, but better when served up full grown, especially the females, just before they have deposited their eggs.

From historians and philosophers we pass to the poets. Their praises and similes here are legion. Homer compares garrulous old men;

> "To the cicadas, which infest
> The woodlands, and sitting upon the trees
> Utter a delicate voice."[1]

And Virgil,

> "And shrill cicadæ all the woodland tire" (Southey).[2]

which leaves it apparent to our minds, that their music did not strike our poet as being very melodious.

Since we hear the cicada generally during the hottest part of the day, Virgil says again:

> "Under a scorching sun the woods resound
> With shrill cicadas' notes."[3]

In fine, no praises seemed too extravagant to lavish upon the harvest-fly. The ancients called them "the love of the Muses," "Sweet prophet of summer," etc. They likened them to the gods. No sound seemed to awaken in their minds memories so pleasant, as the truly delicate voice of the cicada. We can, perhaps, sympathize with them here, when we hear the peeping of the frogs at the opening of spring, the glad token that the long and cold winter is past. Especially can we feel such emotions when we hear them after a long absence from home.

Antipater is said to have preferred the notes of the cicada to the swan's. But all others' praises fall short, compared with what Anacreon bestows upon our little friend. And truly most rapturously he sings

> "Oh thou of all creation blest,
> Sweet insect! that delight'st to rest
> Upon the wild wood's leafy tops,
> To drink the dew that morning drops,
> And chirp thy song with such a glee,
> That happiest kings may envy thee!
> Whatever decks the velvet field,
> Whate'er the circling seasons yield,
> Whatever buds, whatever blows,
> For thee it buds, for thee it grows.
> Nor yet art thou the peasant's fear,
> To him thy friendly notes are dear;
> For thou art mild as matin dew,

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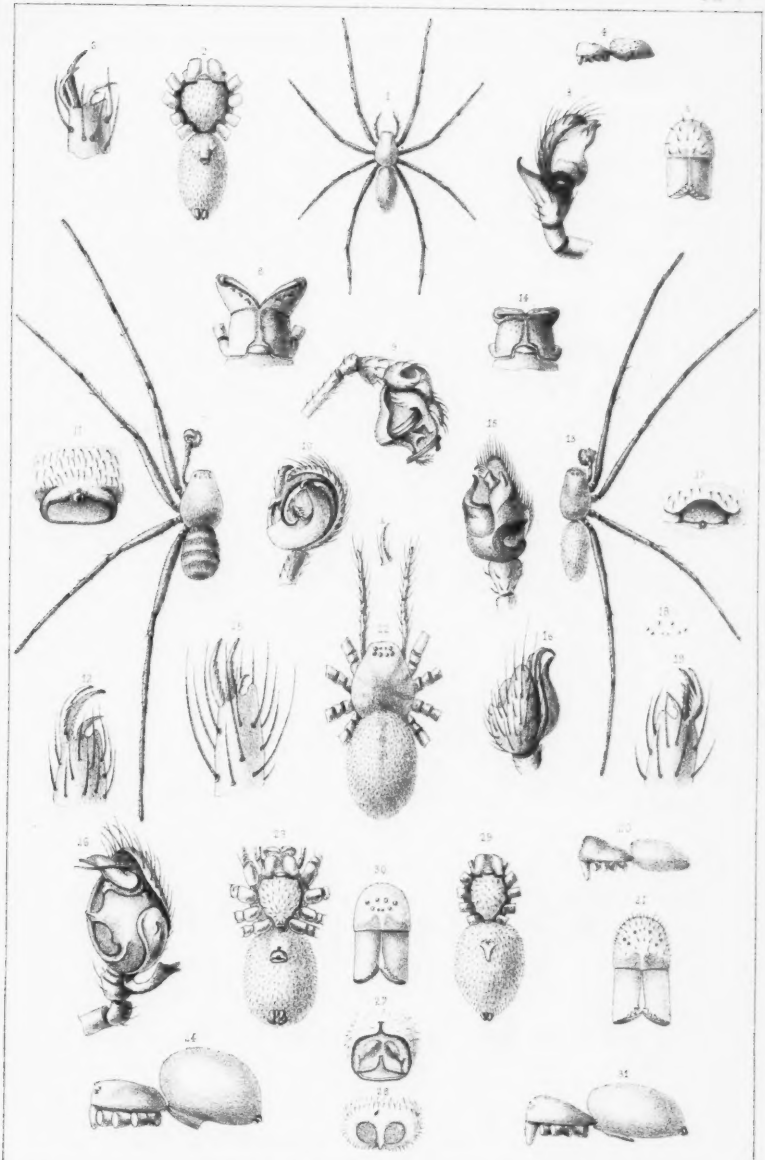
[1] Il. Book III. [2] Geog. III, 328. [3] Bucol. II.



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CAVE SPIDERS OF KENTUCKY, ETC.

And still, when summer's flowery hue
Begins to paint the bloomy plain,
We hear thy sweet prophetic strain;
Thy sweet prophetic strain we hear,
And bless the notes, and thee revere!
The Muses love thy shrilly tone;
Apollo calls thee all his own;
'Twas he who gave that voice to thee,
'Tis he who tunes thy minstrelsy.
Unworn by ages' dim decline,
The fadeless blooms of youth are thine.
Melodious insect! child of earth!
In wisdom mirthful, wise in mirth:
Exempt from every weak decay,
That withers vulgar minds away;
With not a drop of blood to stain,
The current of thy purer vein,
So blest an age is passed by thee.
Thou seem'st a little deity."[4]

Now after singing the praises of our little friend, the cicada, in not, I hope, too extravagant a vein, we pass to a brief description of his singing apparatus, and learn how he makes his music, and see how wonderful and complicated that organ really is.

Réaumur made numerous dissections of the cicada, and was the first to describe accurately the mode of production of its music. But as these dissections can easily be made, and the insects plenty, each one may investigate quite well for himself. A careful examination of the insect is however necessary, as the whole musical apparatus is within the abdomen in the first ring.

Upon the abdomen of the male, are seen two close fitting scales, rounded at the free end, and straight where they join the body. These can be lifted to a considerable degree, but prevented to too great an extent by two projections which serve to keep the valves (or opercula more properly) in place. Removing the valve, we observe beneath a cell, a little box, so to say, at the bottom of which lies a circular membrane of exceeding thinness, and presenting all the colors of the rainbow. Réaumur calls it the mirror. It resembles the drum of the ear, and affords much pleasure even in a cursory examination. Imagine for the time two cells, with each a window opening into the internal parts of the body, and concealing machinery which works the apparatus. Each cell is divided into three parts by a triangular plate; the upper boundary being a semilunar membrane, which may be con-

[4] Ode XXXIV, Moore's Trans.

tracted or relaxed at the pleasure of the insect, and the part containing the mirror. But the real organ is only seen from the back. It is found a little below the external covering of the animal, directly facing the membranous drumhead in the first cavity. It consists of a very thin membrane, wrinkled, and can be moved back and forth within its circumference, causing a snapping noise, something like the sounds given out by the live insect. Attached beneath each drumhead are fibres of muscle, which join near the inside edge of the mirrors, and form one, which is inserted to the back. If we pull one, or both these muscles, the well known sound is emitted. When these muscles are contracted or pulled, the drumhead falls in; and when relaxed, the drumhead springs into position by its own elasticity. We can therefore imagine how, when these muscles are contracted with sufficient rapidity, the insect sings his song. The musical instrument is therefore, simply a little drum. The sound passes through the first cell, and its pitch is regulated by the movable semilunar membrane. Then striking against the mirror the sound may be reinforced; and then passes out by the valves which regulate its intensity in some manner. For on pressing the valves closely to the body, little sound, if any, is emitted; raise up the valves as high as possible and the sound is most intense.

The insect may be kept captive for some time, and in this condition much may be learned from actual observation. Boys in Surinam fasten straws to the cicadas and run with them through the streets. Its "noise" has been compared to the sound given out by whirling a piece of cardboard attached to a string, rapidly through the air.

The cicada, though as in the seventeen-year species maturing for several years, lives but for a brief season. With the expiring summer he takes his leave, and testifies with his lingering life, a glad song which grows feebler and feebler, till finally it dies away sadly but beautiful like the summer he carries with him.

ON THE BREEDING OF CERTAIN BIRDS.

BY DR. ELLIOTT COUES, U. S. A.

No. 2.

In the treeless portions of Montana, the streams that meander through the boundless prairies constantly present the feature of "cut-banks," which I mentioned in my last article as the breeding resort of various hawks. This furnishes other exceptional instances of terrestrial nidification, which may well be placed on record.

Probably no birds vary more in their modes of nesting according to different circumstances than swallows; and certainly none adapt themselves more readily to their surroundings. On the face of the cut-banks, as would be expected, thousands of cliff swallows fasten their bottle-shaped nests of mud; but who would have anticipated the breeding amongst them of barn swallows, in holes in the ground? In various parts of Montana, where there were no trees, and no breaks in the prairie excepting the "coulés" (ravines) and streams, I frequently saw troops of barn-swallows, and for some time wondered where they bred. At length Mr. Batty, one of my assistants, found some nests of this species, and settled the question. The nests were placed in little excavations on the face of the banks, deep enough to be fairly called "holes," and answering all the purpose of the corner of the rafters, which the bird usually selects. Mr. Batty surmised that in some instances at least, the bird enlarged and adapted, if it did not actually dig out, the excavation; but of this I do not feel sure. It seems more probable that choice was made of the natural indentations of the bank, just as was the case with the hawks already mentioned.

At one of our camps on a small tributary of Milk River, on the boundary line of the United States and British America, two nests of the golden eagle (*Aquila chrysaëtes*) were found within a mile of each other, each capping a piece of cut-bank.

Viewed from the prairie side they seemed, and actually were, to all intents and purposes, placed on the bare level ground; from the reverse aspect the natural instinct of nesting on a crag was

seen to be fulfilled. But one would think that if an eagle were to stoop to nest in such a place, the bird would choose the highest and boldest embankment in the vicinity. Such was not, however, the case. One of the nests which I visited was rather upon the brow of a little hill than the edge of a cliff. The distance from the bed of the stream was no more than an easy gunshot, and the inclination was so slight that I readily walked up the embankment, gun in hand. The nest was composed of sticks, some of which were as large as one's wrist, brushwood and bunches of grass and weeds with masses of earth still adhering to the roots. It was about four feet across in one direction, and three in the other, the shape being suited to the slight projection of ground on which the nest rested; the matted mass of material averaged about six inches deep. The other nest was described to me as considerably larger. Both were empty and apparently deserted. Although I saw no eagles just at this spot, I do not hesitate to identify the nests as those of the species mentioned, for the birds were very frequently — almost every day — seen in the neighboring Sweetgrass Hills. There do not appear to be any bald eagles in the country, and the nests were altogether too large to have been those of any kind of hawk known to occur in the region.

Some years ago, Dr. F. V. Hayden brought us from the mountains a pair of harlequin ducks (*Histrionicus torquatus*), and accompanying the specimens was an egg cut from one of them. This fact, coupled with the date of capture (May 31), led to the inference of the breeding of this species in the Rocky Mountains within the limits of the United States. The past season (1874) I have had the pleasure of establishing the fact. At Chief Mountain Lake, near the heart of the Rockies, where the U. S. Boundary line crosses, I found broods of young harlequins still unable to fly, late in August. Several specimens, including the mother of one of the broods, were secured; the adult male was not observed. What is somewhat unusual for ducks, this brood was found in a clear ice-cold mountain torrent, disporting in a pool at the foot of a cascade. The altitude was about five thousand feet. The character of the stream may be clearly recognized in the fact that it was full of beautiful trout of two species, and was also the home of the water ouzel (*Cinclus Mexicanus*). When disturbed, the old bird flew low over the water, while others sank back quietly into the limpid element, till only the head remained above the

surface — just like grebes; some sought refuge behind and beneath the cascade, screened by the whole volume of water that leaped over the projecting rocks. Another brood was seen swimming quietly in one of the side pools near the lake.

With the harlequins was also breeding a species of *Bucephala*. It was not *B. albeola*, but whether *B. clangula* or *B. islandica* is yet undetermined, as I did not take the old male, and as the young ones cannot be determined without comparison of specimens that I cannot make in the field.

The breeding of the Bohemian waxwing (*Ampelis garrulus*) long remained unknown, and to this day my only records of its nesting on this continent have come from Alaska, whence specimens of the eggs were lately brought. It is a matter of satisfaction to be able to attest its breeding in the Rocky Mountains, on, or at any rate very near, the border of the United States. On the 19th of August, while I was at Chief Mountain Lake (this beautiful sheet of water lies across our line), a Bohemian waxwing was shot by my assistant, Mr. A. B. Chapin, who picked it out of a flock of common cedar birds. It was still in the peculiar streaky stage of plumage which is characteristic of the very young bird, and must have been hatched somewhere in the vicinity. Additional evidence in favor of this induction lies in the fact that the cedar birds were breeding at the same time. Several young ones were shot, and Mr. Chapin secured a nest containing four partially incubated eggs. This was late (Aug. 19) even for so tardy a breeder as the cedar bird is well known to be. But the birds were in mountains, and at a latitude (49°) north of their average breeding range. What with the rare ducks just mentioned, the water ouzels, dusky grouse, and the curious little chief hare, *Lagomys princeps*, to say nothing of the aristocratic Bohemians, our familiar friends were here in very select company.

There are some interesting points, all of which may not be generally known, respecting the range of the flickers in this part of the world. In the Red River Valley, and clear away westward on the parallel of 49° to where the Coteau of the Missouri crosses this line, you get nothing but pure *auratus*. I have shot this nearly to the head waters of the Souris or Mouse River. Throughout the greater part of the Missouri region proper — the immense extent of which must be travelled over to be thoroughly appreciated — the curious "hybrid" form prevails. I never saw a speci-

men that did not show the mixture of *Mexicanus*, from any part of the Missouri water-shed beyond the strict limits of the Eastern Province. But at the Rocky Mountains this mongrel breed runs up north into the Saskatchewan region at least, if not farther. In latitude this is more than abreast of the Mouse River area where *auratus* flourishes untouched with red. I have specimens of various grades of "hybridity" from the mountains where the St. Mary's, the Kootenay (or Kootanie) the Belly and other tributaries of the northern waters arise.

Audubon's warbler (*Dendrœca Auduboni*) breeds in the Rocky Mountains at the locality lately specified. Several very young birds were shot in August.

There is something I have not quite made out respecting the breeding range of Sprague's lark, *Neocorys Spraguei*. The bird can hardly be more abundant anywhere than it is in the country west of the Red River and north of the Missouri Coteau. I certainly saw several thousand last year. The present season, at the site of Fort Union (Audubon's original locality), and thence up the Missouri to the mouth of Milk River, I noticed altogether a few hundred perhaps. But the birds were not common, and in all the country west of this I saw none at all until I came upon the head of Milk River, just at the ridge that divides these waters from those of the Saskatchewan. There, among the foothills of the Rockies, the species reappeared. Much the same peculiarity attaches to the breeding range of Baird's bunting. This bird is everywhere over the Mouse River region, and the type came from the Upper Missouri, but during the summer just passed I have failed to find a single one in the whole country from the mouth of the Yellowstone to the headwaters of the Saskatchewan.—*Fort Benton, Montana, Sept.* 9, 1874.

THE COLOSSAL CEPHALOPODS OF THE NORTH ATLANTIC. II.

BY PROF. A. E. VERRILL.

After the first part of this article was printed, I received an interesting letter from the Rev. Mr. Harvey, who, in accordance with my request, has made a new examination of the large arm of

"No 2," preserved in the Museum at St. John's, N. F. He states, in this letter, that all the suckers were originally denticulated around the margin, as suggested by me in the last number of the NATURALIST, and that this fact was previously overlooked on account of the mutilation it had undergone. He has also furnished to me a full series of measurements of its various parts. It has contracted excessively in the alcohol, and is now only thirteen feet and one inch in length (instead of nineteen feet, its original length), the enlarged sucker-bearing portion being two feet and three inches; the large suckers occupy twelve inches; the terminal part bearing small suckers, nine inches; circumference of slender portion 3·5 to 4·25 inches; of largest part 6 inches; breadth of face, among large suckers, 2·5 inches; from face to back, 1·62 inches; diameter of largest suckers outside, ·75 of an inch; inside, ·63 of an inch. It will be evident from these measurements, when compared with those made while fresh and from the photograph, that the shrinkage has been chiefly in length, the thickness remaining about the same, but the suckers are considerably smaller than the dimensions previously given.

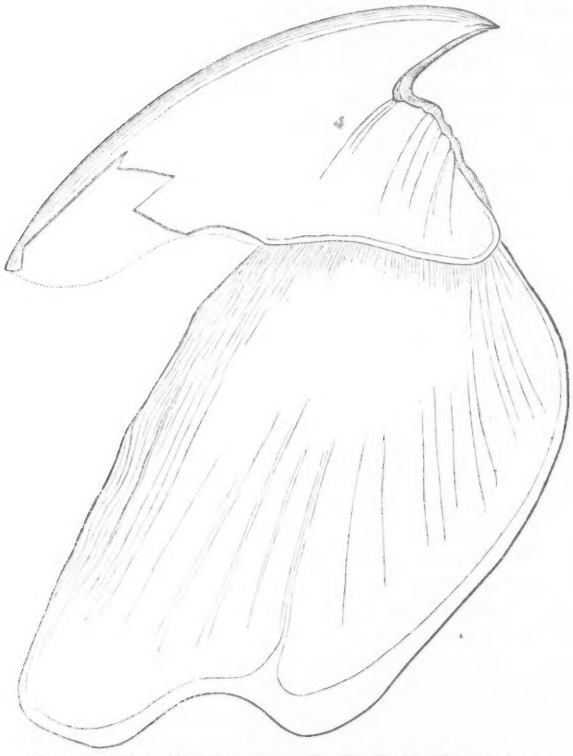
Mr. Harvey also mentions that a specimen was cast ashore at Bonavista Bay, December, 1872, and his informant says that the long arms measured thirty-two feet in length, and the short arms about ten feet in length, and were "thicker than a man's thigh." The body was not measured, but he thinks it was about fourteen feet long, and very stout, and that the largest suckers were 2·5 inches in diameter. The size of the suckers is probably exaggerated, and most likely the length of the body also. It is even possible that this was the same specimen from which the beak and suckers described in my last article, as No. 4, from Bonavista Bay, were derived, for the date of capture of that specimen is unknown to me. The latter, however, was much smaller than the above measurements of the former would admit, and it will, therefore, be desirable to give this one a special number (11).

Another specimen, which we may designate as No. 12, was cast ashore this winter, near Harbor Grace, but was destroyed before its value became known, and no measurements are given.

Architeuthis princeps Verrill, sp. nov., figures 25, 26, 27. This species is based on the lower jaw mentioned as No 1 in my former papers, and on the upper and lower jaws designated as No. 10, in the first part of this article; besides these jaws we only have the

rough measurements of the body of No. 4, and an estimate of the diameter of the sessile arms. The jaws of No. 10 were obtained from the stomach of a sperm whale taken in the N. Atlantic, and were presented to the Essex Institute by Capt. N. E. Atwood, of Provincetown, Mass., but the date and precise locality of the cap-

Fig. 25.



Upper jaw of Architeuthis princeps Verrill. No. 10. Natural size.

ture are unknown. The form of these jaws is well shown in figures 25 and 26. The total length of the upper jaw (fig. 25) is 5 inches; greatest breadth, 1·45; front to back 3·5 inches; width of palatine lamina, 2·32. The frontal portion is considerably broken, but the dorsal portion appears to extend nearly to the

posterior end, the length from the point of the beak to the posterior edge being 3·4 inches. The texture is firmer and the lamina are relatively thicker than in *A. monachus*. The rostrum and most of the frontal regions are black and polished, gradually becoming orange-brown and translucent toward the posterior border, and marked with faint striæ radiating from the tip of the beak, and

Fig. 26.

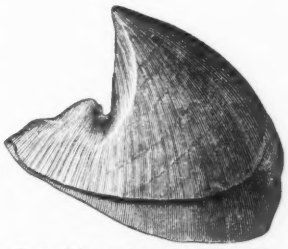
Lower jaw of Architeuthis princeps. No. 10. Natural size. The dotted line shows the portions that are present on the back side.

by faint ridges or lines of growth parallel with the posterior margin; a slight but sharp ridge extends backward from the notch at the base of the cutting edge, and other less marked ones from the anterior border of the alæ. The tip of the beak is quite strongly curved forward, and acute, with a slight shallow groove, commencing just below the tip, on each side, and extending backward only a short distance and gradually fading out. The cutting edge is nearly smooth and well curved, the curvature being greatest toward the tip; at its base there is a broad angular notch, deepest

externally. The inner face of the rostrum is convex in the middle and concave or excavated toward the margins, which are, therefore, rather sharp. The anterior borders of the alæ are convex, or rise into a broad, but low, lobe or tooth beyond the notch, but beyond this they are nearly straight, but with slight, irregular lobes, which do not correspond on the two sides. The anterior edges of the alæ make nearly a right angle with the cutting edges of the rostrum. The palatine lamina is broad, thin, and dark brown, becoming reddish brown and translucent posteriorly, with a thin, whitish border. The surface is marked with unequal divergent striæ and ridges, some of which, especially near the dorsal part, are quite prominent and irregular; the posterior border has a broad emargination in the middle, but the two sides do not exactly correspond. The lower jaw (fig. 26) was badly broken, and many of the pieces, especially of the alæ, are lost, but all that remain have been fitted together. The extreme length is 3·63 inches; the total breadth, and the distance from front to back, cannot be ascertained, owing to the absence of the more prominent parts of the alæ; from tip of beak to posterior dorsal border of mentum, 1·68; from tip of beak to posterior lateral border of alæ, 2·20; from tip of beak to posterior dorsal border of gular lamina, 2·37; from tip of beak to bottom of notch at its base, ·80; tip of beak to inner angle of gular lamina, 1·85; height of tooth from bottom of notch, ·25; breadth between teeth of opposite sides, ·60; from front to back of gular lamina, in middle, 1·75. The rostrum is black, with faint radiating striæ, and with slight undulations parallel with the posterior border; the beak is acute, slightly incurved, with a notch near the tip, from which a very evident groove runs back for a short distance, while a well marked, angular ridge starts from just below the notch, and descends in a curve to the ala, opposite the large tooth, defining a roughened or slightly corrugated and decidedly excavated area, between it and the cutting edges; the cutting edge below this ridge is nearly straight, or slightly convex; the notch at its base is rounded and deep and strongly excavated at bottom; the tooth is broad, stout, obtusely rounded at summit, sloping abruptly on the side of the notch, and gradually to the alar edge. The anterior edge of the alæ, beyond the tooth, is rounded and strongly obliquely striated: it makes, with the cutting edge, an angle of about 110°. The inner surfaces of the two sides of the internal plate of the rostrum form an angle of about 45°.

The lower jaw of No. 1 (fig. 27) is represented only by its anterior part, the alæ and gular laminæ having been cut away by the person who removed it. It agrees very well in form and color with the corresponding parts of the one just described, but is somewhat smaller. The lateral ridges of the rostrum are rather more prominent, and the area within it is narrower and more deeply excavated, especially at the base of the notch, where the excavation goes considerably lower than the inner margin. The notch is narrower and not so much rounded at its bottom. The tooth is about the same in size as that of No. 10, and appears to be even more prominent, because the edge of the alæ is more concave at its outer base; it is also more compressed and less regularly rounded at summit; the anterior edge of the alæ seems to rise into another low lobe beyond the concave portion. This jaw measures 1·30 inches from the tip to the posterior dorsal border of mentum; ·65 from tip to the bottom of the notch; ·16 from bottom of notch to tip of the tooth.

Fig. 27.



Part of lower jaw of Architeuthis princeps. No. 1. Nat. size.

Both these lower jaws agree in having a very prominent tooth on the alar edge, with a large and deeply excavated notch between it and the cutting edge, and in this respect differ from the two lower jaws of *A. monachus* in my possession, for in the latter the tooth or lobe is low and broad, and scarcely prominent, while the notch is narrow and shallow. This seems to be the best character for distinguishing the jaws of the two species. But they also differ in the angle between the alar edge and the cutting edge of the rostrum, especially of the lower jaw, for while in *A. monachus* this is hardly more than a right angle, in *A. princeps* it is about 110°. Moreover, the darker color and firmer texture of the jaws of the latter seem to be characteristic.

The proportions of the body seem to be quite different, if we can judge by the measurements given of the specimen (No. 1) which was found dead and floating at the surface of the water, at the Banks of Newfoundland, by Capt. Campbell, of the schooner

B. D. Haskins, from Gloucester, Mass., in October, 1871.[1] It is stated that this specimen was measured, and that the body was fifteen feet long, and four feet and eight inches in circumference. The arms were badly mutilated, but the portions remaining were estimated to be nine or ten feet long and about twenty-two inches in circumference, two being shorter than the others. This would indicate a much more elongated form of body than that of *A. monachus*. If these proportions be correct, the body of No. 10 must have been about nineteen feet in length, and five feet and nine inches in circumference.

This specimen is probably the largest invertebrate hitherto actually examined by any naturalist. Larger cephalopods may possibly have been seen by mariners, but most of their statements of size are only rude estimates, and are nearly always much exaggerated.

Notes on specimens described by other writers. We are mainly indebted to Professor Steenstrup and to Dr. Harting for our knowledge of the specimens preserved in European museums, or cast ashore on the European coasts. Professor Steenstrup has given interesting accounts, compiled from contemporary documents, of a specimen taken in 1546, and of two specimens of huge cephalopods cast ashore at Iceland in 1639 and 1790, and has also described and figured[2] the jaws of another specimen o *A. monachus*, obtained at Jutland in 1853. In the same memoir, of which I have seen only the first part, there are references to a description and figures of *A. Titan*, obtained in 1855, by Capt. Hygom, in N. Lat. 31°; W. Long. 76.° The latter specimen appears to be the same that Harting[3] mentioned under the name of "*Architeuthis dux* Steenstrup," as collected at the same time and place, and of which he published an outline figure of the lower jaw, copied from a drawing furnished to him by Steenstrup. Harting states that the pen or "gladius" of this specimen is six feet long. Many important parts of this specimen were secured, and I

[1] See the American Naturalist, Vol. vii, p. 91, Feb., 1873.

[2] In a paper, of which I have only seen some proof-sheets, given by him to Dr. Packard, entitled "Spolia Atlantica." Whether this memoir has been published I do not know. The plate (I) that I have seen, is marked "Vid. Selsk. Skrifter V. Række, naturv. og mathem. Afd. iv, Bind;" and there are references to three other plates illustrating *A. Titan*, etc.

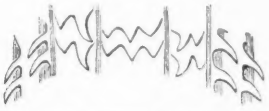
[3] Description de quelques fragments de deux Céphalopodes gigantesques. Publiées par l' Académie Royale des Sciences à Amsterdam. 1860. 4to, with three plates.

regret that I have been unable to see the figures and description of it, referred to by Harting as forming part of Prof. Steenstrup's memoir, then unpublished. But to judge by the outline figure given by Harting, it is a species quite distinct from those described above. The lower jaw resembles that of *A. monachus* more than *A. princeps*, and is a little larger than that of our No. 5 (see fig. 6). The beak is more rounded dorsally, less acute, and scarcely incurved, the notch is narrow, and the alar tooth is not prominent.

Harting, in the important memoir referred to, describes specimens of two species, both of which are evidently quite distinct from all those enumerated above.

The first of these (Plate I) is represented by the jaws and buccal mass, with the lingual dentition, and some detached suckers, preserved in the museum of the University of Utrecht, but from an unknown locality. These parts are well figured and described, and were referred to *Architeuthis dux* by Harting. But the character of the dentition (fig. 28) is so totally different from

Fig. 28.



Teeth of Loligo Hartingii Verrill. Enlarged.

what I have found in *A. monachus* that it will be necessary to refer this species to a different genus, if not to a distinct family. The form of the lower jaw is quite unlike that of *A. dux*, for the beak is very acute, the cutting edge is concave, the notch shallow and broad, and the alar tooth is somewhat prominent. The size is about the same as our No. 5. The suckers figured are from the sessile arms, and agree pretty nearly with those of *A. monachus* (see fig. 3). The edge is strengthened by an oblique, strongly denticulated ring. The internal diameter of the largest of these suckers is ·75 of an inch; the external, 1·05 inches. They were furnished with slender pedicels, attached obliquely on one side. The lingual teeth (see fig. 28 copied from Harting,) are in seven regular rows, and resemble closely those of *Loligo* (fig. 9). In fact, I cannot find, in the figures and description, any character by which this species can be separated from *Loligo*, and at the same time it is evident that it is a species distinct from all others

known. I would, therefore, propose to designate it by the name of *Loligo Hartingii*.

The other species described by Harting was represented by the jaws and pharynx, an eye, a part of one of the sessile arms, and of one of the long tentacular arms, preserved in the museum of the Zoological Garden of Amsterdam. They were taken from the stomach of a shark, captured in the Indian Ocean. Harting referred this specimen to the genus *Enoploteuthis*, and doubtfully to the species described by Owen under the name of *E. unguiculata*, from a specimen in the Hunterian museum, collected between Cape Horn and Australia by Banks and Solander, on Capt. Cook's first voyage. The jaws of this species are very sharp and strongly incurved, and a little smaller than those of the *Loligo Hartingii*.

Instead of circular suckers with denticulated margins, the arms bear two rows of large sharp incurved hooks or claws, arising from large, swollen, muscular bulb-like bases, attached to the arms by short pedicels. The lingual dentition is also quite peculiar, but the teeth are arranged in seven rows, as usual.

Mr. Kent, in the article already referred to,[4] mentions a sessile arm of a giant cephalopod, which has been long preserved in the British Museum, but of which the origin is unknown. He states that it is 9 feet long; 11 inches in circumference at the base, tapering off to a fine point. There are from 145 to 150 suckers, in two alternating rows, those at the base being half an inch in diameter. The relatively small size of the suckers and great length of the arms show that this arm cannot belong to the same species as our *Architeuthis monachus*, which Mr. Kent thought probable. But as the arms of *A. princeps* and *Loligo Hartingii* are still unknown, it may belong to one of those species, or it may belong to the species observed, but not captured, by the officers of the "Alecton," in 1861, near Teneriffe, and named *Loligo Bouyeri* by Crosse and Fischer, but known only from the imperfect descriptions of it given by the officers, and a sketch of it prepared while the crew were making unsuccessful attempts to get it on board.

The body of this one was estimated at 15 to 18 feet in length, with the arms somewhat shorter.

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[4] Proceedings Zoological Society of London, for 1874, page 178.

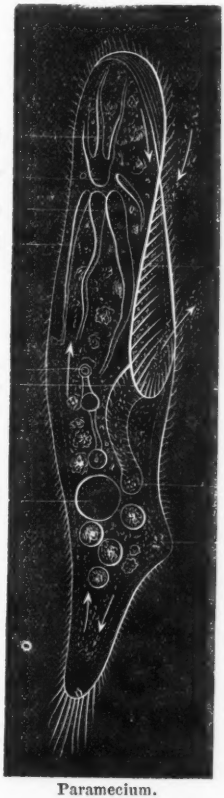
LIFE HISTORIES OF THE PROTOZOA AND SPONGES.

BY A. S. PACKARD, JR.

VII. THE INFUSORIA (CILIATA).

THOUGH the term Infusoria has usually been applied to nearly all the Protozoa provided with cilia or flagella, it is now restricted to the highest division of the Protozoa. Instead of an attempt to define the group, the following brief description of some of the well-known forms will perhaps best show how they differ from the Flagellata, with which they are most apt to be confounded.

Fig. 29.



Paramecium.

One of the simplest and most abundant forms is Paramecium. The accompanying figure (29), copied from Clark's "Mind in Nature," represents *Paramecium caudatum*, of Ehrenberg.[1] This animalcule is a mass of protoplasm, representing, perhaps, a cell. In the body-mass are excavated a mouth and a throat leading to a so-called stomach or digestive cavity. Two hollows in the body form the contractile vesicles, and another cavity forms the reproductive organ. Prolongations of the body-mass form the cilia, which characterize the Infusoria and give their name, Ciliata. No specialized tissues composed of cells exist in these organisms, and they are regarded as on the whole representing a single cell. Some authors, as Claparède, regard them as composed of several cells, but the whole animal, though performing functions nearly

[1] Fig. 29. A view from the dorsal side, magnified 340 diameters. H. the head: T. the tail; *m*, the mouth; *m* to *g*, the throat; *a*, the posterior opening of the digestive cavity;

as complicated as those of sponges, low worms and radiates which have bodies composed of many cells, should be regarded as made up of indifferent or unorganized sarcode or protoplasm, somewhat like that of the bodies of the embryos of the higher animals in their earliest stages.

Paramecium has an elongated, oval body "with one end (H) flattened out broader than the other, and twisted about one-third way round, so that the flattened part resembles a very long figure 8." In this form, as in Stentor (Fig. 30), as Clark remarks, "we have the mouth at the bottom of a broad notch or incurvation, and the contractile vesicle on the opposite side, next the convex back, whilst the general cavity of the body lies between these two." The arrows in the figure represent the course of the particles of indigo with which Clark fed his specimens, "as they are whirled along, by the large vibrating cilia (v) of the edge of the disk, against the vestibule of the mouth." During the circuit the food is digested, a mass of *rejectamenta* is formed near the protuberance, a, which has appeared a short time before. This finally opens, allows the rejected matter to pass out and then closes over, leaving no trace of an outlet. This and other Infusoria seem, then, to have a definite digestive tract, hollowed out of the parenchyma of the body.

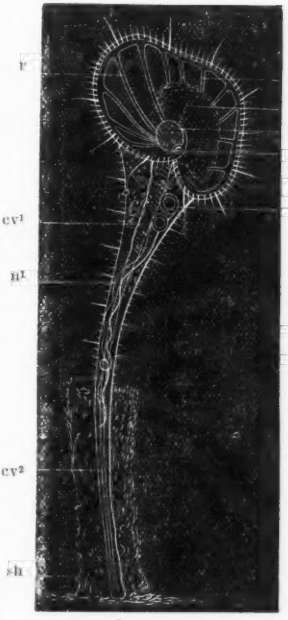
"The system," says Clark, "which is analogous to the blood circulation of the higher animals, is represented in Paramecium by two contractile vesicles (cv, cv^1, I, II, III), both of which have a degree of complication which, perhaps, exceeds that of any other similar organ" in these animals. When fully expanded they appear round, as at cv; but when contracted they appear, observes Clark, as "fine radiating streaks, and as the main portion lessens they gradually broaden and swell until the former is emptied and nearly invisible, and they are extended over half the length of the body. In this condition they might be compared to the arterial vessels of the more elevated classes of animals, but they would at the same time represent the veins, since they serve at the next moment to return the fluid to the main reservoir again, which is effected in this very remarkable way." The contents of these vesicles is a clear fluid.

The reproductive organ in Paramecium is a small tube (n), only seen at the reproductive period when the eggs (n) are fully grown.

cv^1, the anterior and cv, posterior contractile vesicles; I, II. III, the radiating canals of cv^1; n, the reproductive organ; v, the large vibrating cilia at the edge of the vestibule. —After H. J. Clark.

Clark says that the eggs are arranged in it "in a single line, one after the other, at varying distances." It usually lies in the midst of the body, and extends from one-half to two-thirds of the length of the animal. "According to Balbiani's observations upon a closely allied species, when the eggs are laid they pass out from the ovary through an aperture near the mouth" (Clark).

b Fig. 30.



Trumpet Animalcule.

In the Trumpet animalcule (Fig. 30, *Stentor polymorphus* of Ehrenberg, after Clark[2]) we have a higher grade of development than in Paramecium, the animalcule attaching itself at one end, and building up a slight tube in which it contracts when disturbed; an anticipation in nature of the worm in its tube. Prof. Clark has studied in this animalcule certain circular bands within the edge of the disk, from which arise twelve very thin stripes (*rr*) which converge towards the mouth (*m*). These bands are evidently, he says, in close relation with the mouth and cilia, the most active organs of the animal, and he concludes that it is a nervous system.

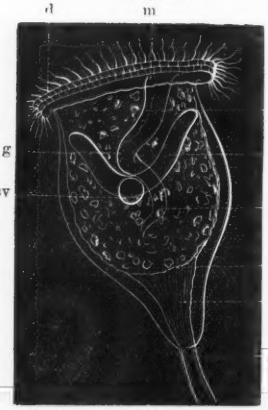
The most complicated form of all among the Infusoria is the Vorticella, or bell-shaped animalcule. These forms are very common on submerged plants and leaves, appearing to the naked eye like mould. Their motions, as they suddenly contract and then

[2] "*Stentor polymorphus*, magnified 130 diameters, expanded and bent slightly over towards the observer; the mouth, *m*, next the eye, and the dorsal edge in the distance. *a*, posterior end; *sh*, the tube enclosing *a*: *c*, the ciliated border of the disk (*s*); *b*, the larger, rigid cilia; *cv*, the contractile vesicle in the extreme distance, seen through the whole thickness of the body; cv^1, cv^2, the posterior prolongation of *cv*, in the distance; *r*, r^1, the circular and radiating branches of the nervous system; *n*, n^1, the reproductive system; extending from the right side, at *n*, posteriorly, but towards the eye at n^1 (Clark).

shoot out their bell, mounted on a long stalk, are very interesting.

Fig. 31.

Fig. 32.



Bell-shaped Animalcule, natural size; and one enlarged.[3]

They form the most available and attractive infusoria for study and amusement. The throat is quite distinct, while the nucleus is the most conspicuous organ of the body. The digestive cavity is "one vast hollow," in which the whole mass of food revolves in a determinate channel (Clark). In fact, so highly developed are these Infusoria that they seem to anticipate certain low worms to which they bear a certain resemblance, and indicate that the worms may have sprung either from the Infusoria or early organisms like them.

Bütschli claims to have discovered that lasso cells like those in the Hydra and jelly fishes are developed in a certain infusorium named by him Polykrikos.

The Infusoria may be divided into three groups; 1, represented by Paramecium; 2, by Vaginicola and Vorticella, and 3, by Acineta (Fig. 33, H). This latter form is not ciliated, the body is stalked and in front prolonged into slender suckers, each terminating in a mouth. At one time Stein supposed that the Vaginicola or Vorticella passed into an "Acineta-form," but Claparède disproved this and Stein retracted his opinion.

Development. The different modes of development among the Infusoria are still involved in doubt. The best observers have advanced theories that have appeared sound, and then revoked them. All agree, however, that the simplest and commonest mode of development is fission, a process analogous to the ordinary

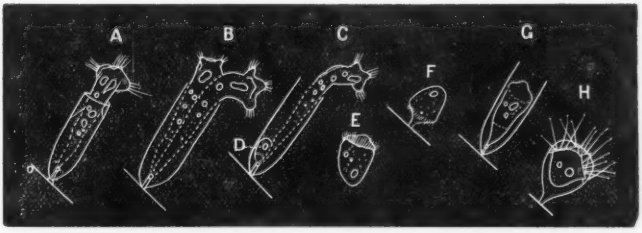
[3] Fig. 31 "*Epistylis flavicans* Ehr., a single, many-forked colony of bell animalcules, slightly magnified. Fig. 32, one of the animalcules magnified 250 diameters. *p*, the stem; *d*, the flat spiral of vibrating cilia at the edge of the disk; *ms*, the muscle; *m* to *s*, the depth of the digestive cavity; *m*, the mouth, *g*, *g*¹, the throat; *l*, the single vibratory lash, which projects from the depths of the throat; *cv*, the contractile vesicle: *n*, the reproductive organ" (Clark).

self-division of the nucleus of eggs, and the primary mode of growth in both animals and plants, not involving the idea of sex.

As a good example of *fission*, by which all Infusoria are supposed to multiply their kind, though some may at certain times reproduce from eggs, we may cite a case observed by Clark, the full account of which is given in his admirable "Mind in Nature." He observed a *Stentor polymorphus* divide in two. The first change taking place is in the contractile vesicle, which divides into two distinct vesicles. The mouth of the new Stentor is formed in the middle of the under side, first appearing as a shallow pit, around which arises a semicircle of vibratile cilia. The new mouth deepens, the throat is hollowed out; all this taking place before any external sign of division appears. But in the course of two hours the body splits asunder, and two new individuals appear, each exactly like the other.

In Vaginicola there is a modification of this simple process, which is more like true gemmation or budding, and is accompanied by a process of encysting. Our figures of the mode of development

Fig. 33.



Development of Vaginicola.

are taken from a short paper by C. J. Müller. He first traced the fission of this infusorium (Fig. 32, A), which takes place in the following manner. After the animal has withdrawn within its case, and assumed a pear-shaped form, its cilia, meanwhile, apparently lost, a conical fissure appears at the base, and soon after "a wavy line of division shows itself at the upper extremity of the animalcule;" the two fissures enlarge and meet; pulsating vesicles become active on both sides of the line of fission, and cilia begin to grow out, until at the end of an hour, two separate animals are formed, which soon afterwards appear as in Fig. 33, B.

Now begins a new process; the production of a free swimming embryo. On one of the two Vaginicolas is developed "a delicate ring or band at about one-third its length from the lower extremity." Then it contracts in its cell, becomes quiet (as in Fig. 33, C, D) and from the ring or band develops a new circle of cilia, the former ones having disappeared. It then swims off as at Fig. 33, E, darting about rapidly until it attaches itself to a piece of Conferva, as at Fig. 33, F. After some hours, perhaps twenty, a fringe of cilia begins to appear on the upper end, the old ones begin to be absorbed, and the tube arises, as at Fig. 33, G, and a new Vaginicola appears. Stein had some years previous made similar observations on *Vaginicola crystallina* Ehr., and thought he had traced their further development into a form resembling Acineta (Fig. 33, H), but this proved afterwards to be a young parasitic Acineta, a suctorial Infusorian.

We have seen that Vaginicola passes through a resting stage, withdrawing into the case in which it lives, and being for a time inactive. Stein has shown that all the Vorticellinæ "at an earlier or later stage of their development become encysted, by drawing in their ciliated disk and contracting their bodies into a ball; at the same time secreting around themselves a gelatinous mass which solidifies into a firmer elastic covering." Fig. 34, G, after Stein, shows a Vorticella thus encysted. After becoming thus encysted the interior becomes homogeneous, as in Fig. 34, H. From this cyst the Vorticellæ arise directly.

Now a second mode of development, and the simplest, has been observed by Stein, *i. e.*, that of monad-like young which result from the breaking up of the cyst. While examining a cyst Stein observed that it burst, and the free contents "remained as a round, transparent limpid drop of jelly, of about the same diameter as the cyst, in which some thirty embryos, of the form of *Monas colpoda* or *Monas scintillans*, sailed about with varied and active motion, as if in a little ocean." These embryos resulted from the breaking up of the band-like nucleus. This breaking up did not take place "by successive acts of division, but in the nucleus, round disks become marked off contemporaneously, at the most distant points; whilst the intermediate substance of the nucleus becomes re-absorbed."

It thus seems that the Ciliata pass through a flagellate or monad condition. Stein regards the above described propagation by the

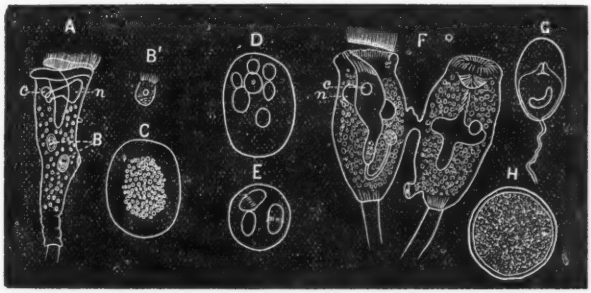
change of the whole inner encysted body of a Vorticella into numerous embryos, as the equivalent of the sexual propagation of the higher animals. We also quote Stein's summary of the cycle of changes undergone by the Vorticella: "We may thus ideally arrange the different stages of development through which the *Vorticellæ* pass; the largest end their lives by becoming encysted; the whole of the contents of their bodies then passes into embryos, to which the dividing germ-nucleus first gives origin.

"The embryos become fixed, develop from their posterior extremity a stalk, which is at first not contractile, and gradually change their monad-like bodies into that of a common Vorticella.

"As soon as this has taken place, their very much smaller size only distinguishes them from the perfect Vorticellæ. Even in this imperfect condition they frequently multiply by continual division and in a subordinate degree by external gemmation. This power of multiplication in the imperfect state, however, is one of the most certain criteria that we have to do with an alternation of generations. * * * * Finally, the last generation become encysted, not to re-awake to an independent existence, but to break up into a swarm of embryos."

Let us now look at the development of *Epistylis plicatilis* as studied by Claparède. Fig. 34, A, represents an individual con-

Fig. 34.



Development of Epistylis.

taining several embryos (B) and opposite the lower one on the right side is a projection, through which the embryo at B' has passed out. The specimen figured at B' is a fair example of the embryos of species belonging to six families of Infusoria, and

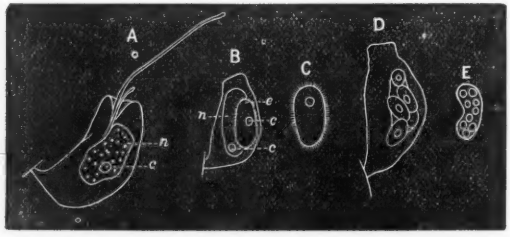
may, perhaps, serve as a typical example of most Infusoria at the time of birth. This young stage may, then, be contrasted with the embryos of the Flagellata, which are of a much simpler form, resembling the zoospores of the algæ and lower Protozoa.

The embryos of the Infusoria arise from the nucleus, which corresponds to the ovary of the higher animals. The nucleus is a curved, oblong, oval body, represented in Figs. 34, A, *n;* 35, E. When the Epistylis is about to reproduce its young, the nucleus sends off a portion which enlarges until it assumes the appearance indicated by Fig. 34, C. It has become round, and contains a central, granular mass, from which the embryos arise. At Fig. 34, D, is a globular mass, detached from the nucleus, and containing several embryos in the first state of development. Fig. 34, E, represents the embryos provided with a circle of cilia, and nearly ready to swim about freely. Claparède did not watch their farther development, but thought it probable that they grew directly into the Epistylis form.

What is the meaning of conjugation in the Infusoria is not clearly understood. Whether it is analogous to sexual union is not certainly known, but it is now thought by Balbiani that the smaller individuals found conjugating with the larger are males, and he even thinks that some Infusoria contain spermatozoa. Fig. 34 represents an Epistylis conjugating, each one provided with two buds; the bud of the individual on the left is conjugated with that of the individual on the right hand. Epistylis also passes through encysted stages as indicated at Fig. 34, G and H.

The same mode of development was observed by Claparède in

Fig. 35.



Development of Urnula.

a parasite of the Epistylis, *i. e.*, *Urnula epistylidis* (Fig. 35), which, besides reproducing by fission, also produces ciliated

young. Fig. 35, B, *e*, represents the ciliated young within the body of the parent, B; Fig. 35, C, the free swimming ciliated young. In another specimen Claparède observed the interior of the body subdivide into several masses, as at Fig. 35, D. These masses increase in size and become filled with a number of small corpuscles, with active movements, which finally press through the walls of the Urnula. These are probably spermatozoa, as Stein considers Urnula as the male of Epistylis, contrary to the opinion of Claparède, who regarded it as a Rhizopod, though its ciliated young is, in the light of later studies, sufficient to prove that it is a ciliate infusorian.

As to the sexuality of the Infusoria, Balbiani has advanced the idea that they are in reality hermaphrodite, the nucleus representing the ovary, and the nucleolus the testis, the latter producing bodies which he regards as spermatozoa. Claparède regards this view as well founded, as it had already been suggested by himself, Lieberkühn, J. Müller and Stein that certain Infusoria contained spermatic particles, found not only in the nucleolus, but also in the nucleus, into which they had penetrated from the nucleolus. This has been observed in Paramecium, where, as Claparède quotes as Stein's opinion, that "Fecundation having been accomplished, these zoosperms disappear, and the nucleus then divides in a manner comparable to the segmentation of the egg into a certain number of segments, or reproductive bodies, destined each to give rise to an embryo. The Infusoria, then," adds Claparède, "are androgynous."

It appears, also from the observations of Balbiani, that the Infusoria, as Stentor, Paramecium, Vorticella, etc., have true eggs, each egg consisting of "two hollow membranous spheres, the smaller being enclosed within the other, and separated from it by a considerable interval." The smaller vescicle he regards as the germinal vesicle, and the larger as the vitelline membrane. After the fecundation, "at the end of four or five days, the development of the eggs is complete, and each, with the aid of reagents, displays in a very distinct manner its characteristic elements, namely, vitelline membrane, vitellus, germ-vesicle and germ-spot." Bütschli, however, it should be stated, denies that Infusoria produce spermatozoids which fertilize the nucleus. As to the development of the Acinetæ, self-fission is in them very are, while conjugation is very frequent.

There are, then, two modes of development among the Infusoria (Ciliata):—

1. By fission.

2. By production of internal ciliated embryo arising from eggs.

We have, then, for the first time among the Protozoa, if the observations of Balbiani be correct (though this is denied by good observers), truly sexual animals, producing true eggs and spermatic particles. The same animal reproduces both by fission and by the production of ciliated embryos. Most of them before producing embryos undergo fission. This is comparable to the alternation of generations among the Hydroids, Aphides, etc.

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VIII. THE SPONGIÆ (PORIFERA).

We now come to animals whose bodies are composed of numerous cells, and which produce true eggs, sometimes even with a thin calcareous shell, and genuine sperm cells. The embryo sponge arises from eggs which undergo a total segmentation of the yolk. The free swimming larva later in its life becomes fixed, loses its external cilia, but retains its cellular walls, now composed of two layers, which are supported by silicious or calcareous needles or spicules developed in the inner layer.

To regard such an organism as a Protozoan, or even to compare it with a compound Radiolarian such as Sphærozoum, with its silicious spicules and aggregations of one-celled organisms, would not seem warranted. We have, in fact, in the light of the anatomical investigations of Lieberkühn, Carter and Clark, and the combined anatomical and embryological studies of Hæckel, Metschnikoff and Carter, no grounds for leaving them among the Protozoa. Indeed, one of the most striking illustrations of the value

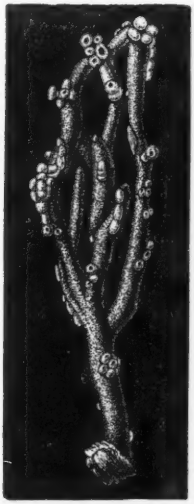
of the knowledge of the early history of an organism is afforded by the embryology of the sponge. Hæckel's discovery that the larval sponge is a planula, though not homologous with the embryo polype or jelly-fish, enables the naturalist to at once decide that the sponge is not a Protozoan, but belongs to a type only less highly organized than the lower polypes, and with more analogy to the Radiates than the Protozoa.

If, under the guidance of the results of the studies of Lieberkühn, Carter, Clark, and particularly of Hæckel and Metschnikoff,

Fig. 36.

Axinella polypoides.

Fig. 37.



Axinella, with a parasitic polype, 2-3 natural size. After Schmidt.

we examine the structure of a sponge, we shall find that in its simplest form it is a hollow, vertical cylinder, fastened by its base, with the mouth opening upwards from a central gastro-vascular cavity, with ciliated epithelial cells lining the cavity, and possessing a surprising degree of individuality. There usually are several mouths, and the cavity usually opens into a labyrinth of chambers connected by passages through the cellular tissue; these round chambers being lined with ciliated epithelial cells. This

body is supported by a basket-work of interlaced needles of silica or lime, developed in the inner layer of cells of the larva.

Such, in brief, is the sponge. Does the fact that in the simplest, immature forms, we have quite a regular body-wall and a single cavity, compel us to range the sponges side by side and in he same natural division with the polypes and jelly-fishes, in the

Fig. 38.

Tethilla polyura. After Schmidt.

Fig. 40.

Hyalonema boreale. Nat. size; with part of stem enlarged. After Lovén.

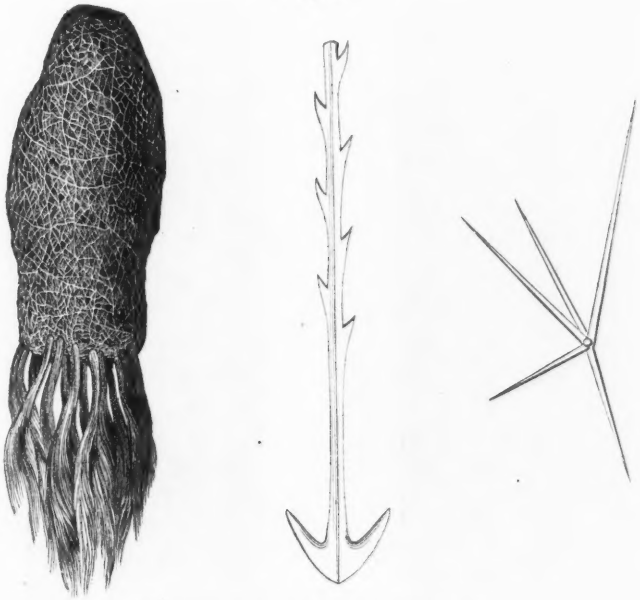
typical forms of which the central cavity acts as a true stomach and the outlet surrounded with tentacles acts as a mouth? Metschnikoff has shown that it would seem to be a violation of the existing principles of classification to place together animals so unlike. The sponges apparently represent a class lower than, but possibly equivalent, systematically, to the polypes and jelly-fishes.

Currents of water, created by the cilia and bearing along parti-

cles of food, enter through the system of mouths, and when the food is absorbed by the cells of the inner lining, they pass out through the larger openings. Both the larger and smaller "mouths" are capable of opening and closing.

The eggs and sperm cells are scattered at irregular intervals among the cells composing the body-walls; the spermatozoa are

Fig. 39.



Pheronema Annæ and Spicules. After Leidy.

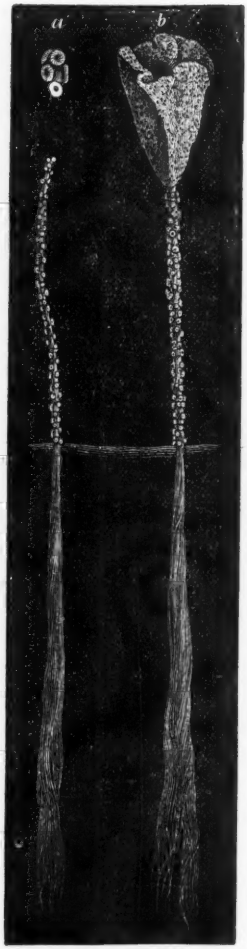
in some species developed in "mother" cells, as in many of the higher animals.

The sponges are by Hæckel regarded as closely allied to the Hydroid polypes, members of the Cœlenterates, a division formed by Leuckart, including the polypes and acalephs. His reasons are based on the fact that the sponges are made up of two layers of cells (ectoderm and entoderm, or outer and inner layer) surrounding a central cavity, and that both reproduce by eggs and spermatozoa, and pass through a "planula" stage.

Fig. 41.

Hyalonema Sieboldii (¼ nat. size). After Schulze.

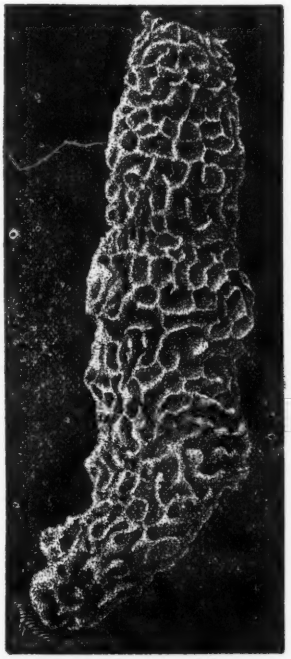
Fig. 42.



Hyalonema with parasitic polypes, embedded half its length in the mud. After Gray.

Gegenbaur and some English naturalists have endorsed this view. Hæckel goes so far as to state that the only character ex-

Fig. 43.



Tuba labyrinthiformis, ½ natural size. After Lütken.

Fig. 44.

Corbitella, ⅔ natural size. After Lütken.

cluding the sponges from the Cœlenterates is the want of lasso cells,[4] but we have seen that the true Infusoria possess them.

[4] Eimer claims to have found true lasso cells in Reniera, a sponge observed by him at Capri; but Carter attributes their presence to a parasitic polype which he detected in this sponge. Eimer on other grounds claims that he has discovered a sponge which affords a passage into the Hydroids. "In an Esperia, in another silicious sponge allied to Myxilla, and in a horny sponge, the surface is studded with small chitinous tubes, which are external prolongations of a similar investment of the whole channel-system, becoming, however, more delicate below, and finally passing into a sarcode-like condition; each of these tubes is inhabited by a retractile, sac-like body, provided with ectoderm, a muscular layer, and entoderm, with thread cells, and with 6–12 long, unbranched tentacles, with cilia and thread cells; below, they pass successively into the common sponge-substance, and generally lie four in each channel, each, however, with

But Metschnikoff has shown that there is no true homology between the sponges and Radiates.

The sponges are divided into (1) the *Myxospongiæ*, represented by Halisarca; (2) the *Fibrospongiæ*, or the silicious sponges, represented by Axinella (Fig. 36, *A. polypoides;* 37, another species of Axinella), the fresh water Spongilla; Thethya, Tethilla (Fig. 38 *T. polyura*); Pheronema (Fig. 39, *P. Annœ* and spines); the glass sponges, such as Hyalonema (*H. boreale*, Fig. 40, from the

Fig. 45.

Dactyocalyx pumicea. After Lütken.

Arctic Ocean; Fig. 41, *H. Sieboldii;* Fig. 42, another Hyalonema, anchored in the mud by its silicious threads) the Venus flower basket, or *Euplectella aspergillum* from the Philippines; the Tuba (Fig. 43, *T. labyrinthiformis*) from the West Indies; the Corbitella from the Moluccas (Fig. 44); and Dactyocalyx (Fig. 45, *D. pumicea*[5]) from the West Indies. The third division of sponges comprises the calcareous sponges (*Calcispongiæ*) represented by the Sycon (*Sycandra ciliata*, Fig. 46), a common little white sponge found on our shores, and in the North Atlantic generally.

its own special chitinous tube. In other sponges (Renieræ) these polypoids were found in a lower stage of evolution, with short or absent tentacles, thread-cells present or wanting, no muscular layer, chitinous investment sometimes strongly developed, annular and projecting—in other instances reduced to a delicate, almost sarcode-like membrane, or almost totally wanting. The idea of parasitism is, according to the author, quite out of the question; the 'polypoids' he constantly regards as the true nutritive zooids of the sponge, and the sponges in which they occur in a more rudimentary shape as intermediate forms, leading to the great majority of sponges without nutritive zooids of any kind." Lütken in Zoological Record for 1872. London, 1874.

[5] This and Figs. 36-38, 40-46, were kindly loaned me by Dr. C. F. Lütken, of the Royal Zoological Museum at Copenhagen. They are from the Tidsskrift for Populære Fremstillinger af Naturvidenskaben. 1871.

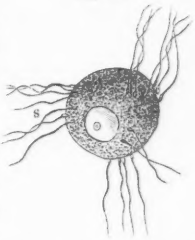
Development. Lieberkühn made the astonishing discovery, confirmed by Hæckel, that sponges were really hermaphrodite animals reproducing by eggs and sperm cells developed in the same individual sponge. Hæckel showed that they were probably developed from the inner (endodermal) layer of cells forming the body, being simply modifications of these endodermal cells, much as the eggs of the higher animals are modified epithelial cells. Fig. 47, from Hæckel, shows one of these cells (of *Sycortes quadrangulata*) with several spermatozoa mingling their protoplasmic contents with the protoplasm of the egg itself.

Fig. 46.

Sycandra ciliata, a calcareous sponge enlarged. After Schmidt.

The endodermal cell transforms into an egg, according to Hæckel, in the following manner. At first provided with a "collar" and flagellum much as in the Codosiga figured on page 42, it begins to draw these in until they disappear; then a nucleus (nucleolinus) appears within the nucleolus of the cell. The egg soon becomes detached from the body wall, and moves about, sometimes penetrating into the exoderm, or "emigrating, in the oviparous species, from the 'stomach' to be fecundated abroad."

Fig. 47.

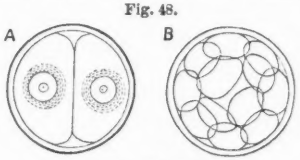


Fusion of spermatic particles with egg of sponge. After Hæckel.

"The spermatozoa are apparently developed through repeated divisions of modified endodermal cells; the 'head' is formed by the 'nucleus,' the tail by the protoplasm of the minute sperm-cells."

After fecundation of the egg, it begins to undergo self-division, splitting into two, four, eight, sixteen, etc., nucleolinated cells (Fig 48, total segmentation of eggs of Halisarca), the process being exactly as in the eggs of nearly all the higher animals including man. This stage of segmentation, like the mulberry mass of the egg after segmentation in the higher animals, Hæckel terms the Morula stage (from its likeness to the mulberry, Morus; see Fig. 48, after Carter). The cells of the

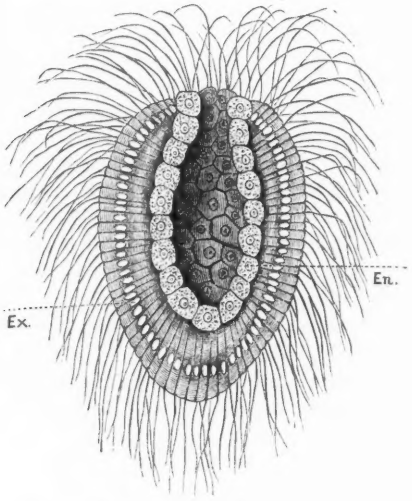
Fig. 48.



Segmentation of egg of sponge.

Morula afterwards become separated into two kinds, a few remaining round, the majority becoming long and prismatic, and provided each with a cilium (flagellum), by means of which it swims about and looks like a "planula" or larval jelly-fish. This stage Hæckel consequently calls the "Planula" stage. The next step is the formation of a "stomach" or internal cavity in the body of the ciliated larva. This stage Hæckel calls "Gastrula." Fig. 49, from Hæckel, represents the gastrula of *Leuculmis echinus*, as seen in optical section, the outer layer (ec-

Fig. 49.



Larva of a Sponge.

toderm) being composed of long prismatic, nucleated cells (*ex*) provided with a lash, while the cells (*en*) of the lining (endoderm) of the cavity are much larger and rounder.[6] After swimming about for a time it becomes fixed by the end of the body to some object, the cavity finally opening out by a mouth. The external cilia now disappear, and others become developed in the cells lining the interior of the cavity.[7] Afterwards the true sponge char-

[6] Metschnikoff shows that this "entoderm" is really an invaginated portion of Hæckel's "ectoderm."

[7] Metschnikoff observed on the contrary that the ciliated external cells are with drawn in the process of growth and line the cavity.

acter of the organism is revealed. The body-wall becomes perforated with pores, which open into the general cavity of the body, while currents of water are maintained by means of the cilia, and flow out through the so-called mouth. This is the "Protospongia" state, and when spicules of silex or lime are developed to strengthen the walls of the body, the young sponge is termed by Hæckel, the "Olynthus."

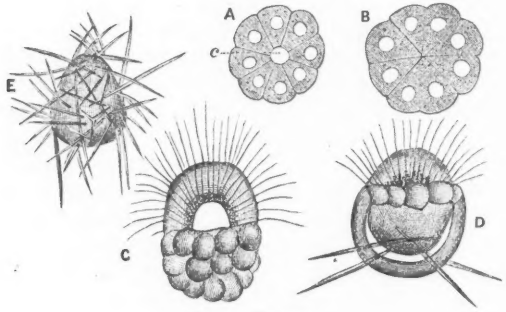
Thus following the course of development as Hæckel supposed to be the case with the calcareous sponges, for he, as Metschnikoff remarks, did not actually observe the stages after the formation of the ciliated larva we obtain a very clear idea of the typical structure of the sponge. I cannot do better than employ the condensed account of the discoveries of Hæckel given by Dr. Lütken in the "Zoological Record" for 1872, with a few corrections taken from Metschnikoff's paper. The Olynthus, the simplest type of the sponge, is a "cylindrical, clavate or pyriform, etc., tube, closed at the extremity by which it is affixed, commonly open by a 'mouth' at the other; the body-wall, enclosing the 'gastric' cavity, is a thin membrane composed of the two layers named above—the '*syncytium*' or exoderm [Metschnikoff's inner layer] a mass of sarcodine with nuclei, the cells of which are so completely fused together that the original cellular structure cannot be made visible through any chemical reaction; if torn mechanically, the fragments will, whether containing one or more or no nuclei, take the shape of Amœbæ and walk about. In this layer[8] the spicula are developed, chiefly of three types—simple, 3-radiate and 4-radiate, anchor-shaped spicula are rare (*Syculmis synapta*, anchoring the animal in the mud bottom); the stellate spicula sometimes occurring are foreign bodies, belonging originally to Didemnia (Ascidiæ). The spicula are invested with a delicate sheath of condensed sarcodine; they contain an axial filament, and are composed of concentric layers, like the silicious spicula; chemically they are composed partly of Co_2, CaO, partly of an organic substance ('spiculin'). The endodermal cells are, like certain flagellate Infusoria, provided with a collar and flagellum; they contain a 'nucleus' (with 'nucleolus'), and often one or two contractile 'vacuola' (water drops); though without 'mouth,' they both 'drink' and 'eat,' or receive

[8] Metschnikoff shows that the spicules really arise from the inner layer.

into their interior, not only fluid, but also minutely diffused solid matter (*e. g.*, carmine), probably through the soft exoplasm between the collar and flagellum. Liberated artificially, they also assume amœboid shapes and motions. On the endodermal cells devolve the whole of the nutritive (digestive, respiratory and secretory) functions; and there can be little doubt that both eggs and spermatozoa are modified endodermal cells."

Hæckel did not observe the development of the larva, his gastrula, into the young sponge. This gap has been filled by Metschnikoff. He observed the course of development in *Sycon ciliatum* (Fig. 50) from the segmentation of the yolk, through the larval state, up to the time when the sponge is fixed and the spicules are

Fig. 50.



Sycon ciliatum.

well developed; in fact, through nearly every important stage in its life. By making a section through the sponge he found eggs and embryos in different stages of development in springtime. The total segmentation occurred as Hæckel describes. Metschnikoff, however, observed that a small "segmentation-cavity" appeared in the egg (Fig. 50, A, *c*) which soon disappeared (Fig. 50, B). As a result of the process of division, a roundish embryo appears, which is made up of a large number of small cells. He was unable to study the mode of origin of the germ-layers. The free-swimming larva (Fig. 50, C) is an oval body, made up of two sorts of cells: those which are small, long and ciliated, and certain large round ones, much fewer in number. The first form a

sort of arch, with a hollow in the middle, surrounding which a large number of very fine brown pigment corpuscles are collected. The next change of importance is the disappearance of the cavity, the upper or ciliated half of the body being much reduced in size. Then the large round cells of the hinder part are united into a compact mass, leaving only a single row. The ciliated cells are gradually withdrawn into the body cavity. Fig. 50, D, shows this process going on. At this period also the larva becomes sessile, and now begins the formation of the sponge spicules, which develop from the non-ciliated round cells. Metschnikoff calls attention to the fact that at this early stage the Sycon passes through a phase which is persistent in the genus Sycyssa. The layer of ciliated cells are gradually withdrawn into the body cavity, until a small opening is left, surrounded with a circle of cilia. These cilia finally disappear, and a few more spicules grow out, and meanwhile the opening disappears. In the next stage (represented at D) a considerable (gastrovascular) cavity appears, which may be seen through the body-walls. At this time, by soaking the specimen in acetic acid, the body of the sponge was seen to consist of two layers, the inner layer of ciliated cells forming a closed sac, enveloped in the spicule-generating layer (representing the entoderm). At this time no mouth-opening was formed, though three-pointed spicules had appeared.

It results from Metschnikoff's observations that the body of the larval sponge is composed of two primary germ-layers, an "entoderm" and "ectoderm," the two germ layers about which we shall hear much more hereafter.

The observations of Carter, made on several additional species both of silicious and calcareous sponges, confirm the results of Metschnikoff as to the later history of the larval sponge, and those of Hæckel as to the mode of segmentation of the egg. Our Fig. 48, A (copied from Carter), shows the total segmentation of the yolk in *Halisarca lobularis* into two portions; these portions farther subdivide, as at Fig. 48, B, until an immense number of small embryonic cells are produced.

Carter observes that the embryos may be found at all seasons, from March through the summer. These observations are not difficult to follow out. We have, by tearing apart a species of Sycandra (or Sycon) perhaps *S. ciliata*, which grows on a Ptilota, found the planula much as figured by Hæckel, Metschnikoff and

Carter, and any one can with patience and care observe the life history of the marine sponges.

It seems, then, that the life history of the sponges consists of the following stages:—

1. Fertilization of a true egg by genuine spermatozoa; both eggs and sperm cells arising from the inner germ-layer.

2. Total segmentation of the yolk, or protoplasmic contents of the egg.

3. A ciliated embryo.

4. A free swimming "planula"-like larva, with two germ-layers, not, however, originating as in the true planula of the acalephs. The planula becomes sessile, spicules are developed in the hinder end of the body, afterwards a gastro-vascular cavity appears, constituting the

5. Gastrula stage.

6. A mouth and side openings appear and the true sponge characters are assumed.

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REVIEWS AND BOOK NOTICES.

THE SPIDERS OF FRANCE.[1]—Mr. E. Simon has just published the first part of a monograph of the Arachnida of France, forming an octavo volume of two hundred and seventy pages, with three plates. Beginning with the Araneæ he describes the Epeiridæ, Uloboridæ, Dictynidæ, Enyoidæ and Pholcidæ. This arrangement is not meant for a natural one, but has been adopted because the work on these families was first finished by the author. The introduction is promised in a future part, but the present volume begins with a short review of the principal descriptive works on

[1] Les Arachnides de France. Par E. Simon, Tome 1, Paris, 1874, with 3 plates 8vo. pp. 270.

European spiders, a list of definitions of terms used in descriptions and some general remarks on classification. The arrangement of families adopted by Simon is the following.

1st suborder. Araneæ oculatæ; Attidæ; Lycosidæ; Oxyopidæ.

2nd suborder. Araneæ veræ; Sparassidæ; Thomisidæ; Palpimanidæ; Eresidæ; Epeiridæ; Ulobaridæ; Theridiidæ; Pholcidæ; Hersilidæ; Urocteidæ; Eryoidæ; Agelenidæ; Dictynidæ; Drassidæ.

3rd suborder. Araneæ graphosæ; Scytodidæ; Dysderidæ;

4th suborder. Araneæ theraphosæ; Filistatidæ; Avicularidæ.

The first suborder is founded on the great development of the head and front legs in the Attidæ, the third is the Senoculinæ of Blackwall, the fourth the Theraphores of Walckenaer, and the second comprises all the other families.

For convenience in identification, tables are given of the most prominent characters of the genera of each family and the species of each genus.

The plates give a figure of one spider from each genus in the Epeiridæ, Ulobaridæ, and Dictynidæ, and a few enlarged figures of feet, palpi and copulatory organs.

The second part containing the Urocteidæ, Agelenidæ, Thomisidæ and Sparassidæ, is to be published next April. The work will be quite useful to students in this country.—J. H. E.

Wheeler's Survey of the Territories.[1]—Judging by the present report, a good deal of geological and biological work has been accomplished in connection with the regular topographical work of the survey. Three parties were in the field, and explored portions of Utah, Arizona, Colorado and New Mexico. Considerable geological work was done, while Dr. J. T. Rothrock and assistant John Wolfe collected nearly 12,000 specimens of plants, representing over 1,100 species. A goodly number of animals were collected, and have been distributed to specialists. The report is accompanied by a number of descriptions of fossil vertebrates from New Mexico by Prof. Cope.

[1] Annual Report upon the Geographical Explorations and Surveys west of the 100th Meridian in California, Nevada, Utah, Arizona, Colorado, New Mexico, Wyoming and Montana. By G. M. Wheeler, U. S. Engineer. Washington, 1874. 8vo, pp. 130, with a map.

Embryology of the Pill-bugs.—An addition of much value to our knowledge of the mode of growth of crustacea is afforded by a Russian embryologist, Dr. Bobretzky in Siebold and Kölliker's "Zeitschrift." He figures the early stages of the pill-bug, or *Oniscus murarius*, of Europe.

The Entomostraca.—An extended and beautifully illustrated memoir by Prof. A. Weissmann, on the structure of *Leptodora hyalina*, a little European Entomostracan, or water-flea, appears in the last number received of Siebold and Kölliker's "Zeitschrift."

BOTANY.

A New Material for Paper.—Considerable attention has recently been called in England to the capabilities of the *Zizania aquatica* as a material for paper. This grass grows in large quantities in swamps on the Canadian shores of Lakes Ontario and Erie, and is known to the native Indians under the name of "Tuscarora," the grains affording an article of diet which is both highly nutritious and palatable, and furnishing food to enormous flocks of wild swans. The culm grows to the height of eight or ten feet, and is of great strength and tenacity. It is said to possess all the good qualities of the "esparto" from the shores of the Mediterranean, now so largely used for paper making in England, and besides, to contain less silex, to require fewer chemicals for its purification, and to make a paper which takes printers' ink with greater sharpness. The great obstacle to its exportation is the heavy freight in consequence of its great bulk; but there is little doubt that if it could be at least partially prepared on this side the water, it might become an important article of commerce. It is stated that a company has been formed for the purpose of obtaining a concession of the land from the Canadian government. The grass is nearly allied to the rice belonging to the tribe Oryzeæ. — A. W. B.

The Movement of Water in Plants. — Dr. W. R. McNab of Dublin has performed a fresh series of experiments on the rate of motion of the sap in plants, and the transpiration of water from the leaves. The plants selected were the cherry-laurel (*Prunus laurocerœus*), elm and privet; and the results obtained were as follows: 1. That under favorable circum-

stances, a rate of ascent of 40 inches per hour can be obtained. 2. That, contrary to the generally received opinion, direct experiment has shown that the upward rapid current of water does not cease in the evening. 3. That checking the transpiration for a short time by placing the branch in darkness does not materially impede the rapid current of water. 4. That the removal of the cortical tissues does not impede the rapid current in the stem, which moves only through the woody (xyleus) portion of the fibro-vascular bundles. 5. That a well-marked rapid flow of fluid will take place in a stem after the removal of the leaves. 6. That fluid will rapidly flow downwards as well as upwards in the wood (xyleus) portion of the fibro-vascular bundles, as seen in a branch in which lithium citrate was applied at the top. 7. That pressure of mercury does not exert any very marked influence on the rapidity of flow, in the one experiment made with a pressure of 110·53 grammes of mercury. — A. W. B.

The Resurrection Fern. — *Polypodium incanium*, the commonest of all the ferns of Florida, is often called the resurrection fern. It grows mostly upon the trunks and branches of the oaks, and I have seen the roofs of old buildings covered with it. During dry weather it shrivels up, and has the appearance of being dead. While in this condition I secured some, wrapped them up in paper, and sent them in April last to Cambridge. On my return to that place in September last, the plants, after having moist moss placed about their roots, were secured to blocks of oak wood hung up in the greenhouse of the Botanic Garden. The leaves unfolded and assumed a bright green color. They now appear to be in a healthy condition. — E. Palmer.

The True Process of Respiration in Plants. — M. Claude Bernard pointed out long ago that the process ordinarily described as that of respiration in vegetables, the decomposition of the CO_2 of the atmosphere, is not properly of this nature at all, but is rather a process of digestion; the true process of respiration being of a precisely similar character in the animal and vegetable kingdoms, viz., an oxidation of the carbonaceous matters of the tissues. M. Corenwinder of Lille in France, has recently confirmed this view from a series of observations on the maple and lilac, proving that true respiration is always going on in a plant, even when concealed by the greater activity of the decomposition

of the CO_2 by the parts containing chlorophyll. He distinguishes two periods in the vegetative season of the plant: — the first period, when nitrogenous constituents predominate, is that during which vegetation is most active; the second, when the proportion of carbonaceous substance is relatively larger, is the period when respiration is comparatively feeble, the CO_2 evolved being again almost entirely taken up by the chlorophyll, decomposed, and the carbon fixed in the process of assimilation or digestion. He found that the proportion of nitrogenous matter in leaves gradually diminishes, while that of carbonaceous matter increases, between autumn and spring. — A. W. B.

Martenia proboscides.—This is a very common plant in Arizona and is very productive. Its large seed pods after being deprived of their epidermis are used by all the Indian tribes of Arizona to ornament their willow baskets. The method resorted to is first to soften by means of water the black pods which are very hard. They readily soften, and are then straightened, split into the requisite strips and worked into willow baskets to form the black ornamentations seen in those made by all the tribes of Arizona.—Edward Palmer.

ZOOLOGY.

An Additional Character for the Definition of Rhynchophorous Coleoptera.[1] — On two former occasions I have invited the attention of my colleagues of the Academy to the relations which the Rhynchophorous Coleoptera bear to the other divisions of that order of insects. In the first of these I endeavored to show that they formed a group which was equivalent to all the others combined. The defining character of the group I stated to be, that the posterior lateral elements (the prothoracic epimera), of the under surface of the prothorax, coalesced on the median line, in such a manner as to form a longitudinal suture behind the end of the prosternum; in all other Coleoptera[2] the prosternum ends in a vacant space, or extends so as to take part in the articulation between the pro- and metathoracic segments. In the second memoir I attempted a sketch of the manner in which the group might be naturally divided into series and families.

[1] Read before the National Academy of Sciences, at Philadelphia, Nov. 5, 1874.
[2] Except in Cossyphus and a few Colydiidæ.

During the progress of the investigations which will terminate in the classification, according to the scheme there proposed, of the genera and species by which the Rhynchophora are represented in our fauna, I have been led to observe an additional character serving to define this great and important complex of genera. This character strengthens greatly the opinion I first announced concerning its systematic value, as an equal of all the other Coleoptera combined.

On separating the head of a Rhynchophore, it is seen that the cranium (I use this word for want of a better term) is globose, and always presents a distinct trace of a median suture on the under surface, corresponding with the gular sutures of other Coleoptera. In the latter, however, these sutures diverge either before or behind, and rarely (Silphidæ and Staphylinidæ), approximate at the middle of their course. Whether the differences in direction of these sutures may or may not, when carefully studied, give indications for the definition of the series into which the normal Coleoptera are now divided upon other characters, I cannot now say. But this much I can assert positively, that in no other but the Rhynchophora, do the lateral elements of the under surface of the head coalesce on the median line, so as to form a straight longitudinal suture extending to the posterior limit of the chitinous part of the head.

In most of the Coleoptera the gular sutures diverge behind, and even when they are obsolete, their posterior termination is indicated by a nick or irregularity in the outline of the infero-posterior margin of the cranium. In the Ptinidæ and Bostrichidæ, by a remarkable exception, the sutures, though distant in front, converge behind.

It will not be in my power, for some time to come, to follow this train of investigation to its limits, and I now make known these imperfect observations in the hope of inducing observers, who are less burdened with a great mass of material urgently pressing for classification, to give some attention to the valuable characters here indicated. — J. L. LeConte, M.D.

Note on Telea Polyphemus.—My note on the synonymy of this species on page 753 of Vol. viii, of the American Naturalist, was printed without proof having been sent to me. In the second paragraph, line six, "this Bombycid" should read "the

Bombyces." No species of Attaci have yet been discovered in Cuba; the very extensive collections of Lepidoptera made in that Island by Professor Poey and Dr. Gundlach having been examined by me (see Grote, on the Bombycidæ of Cuba, Proc. Am. Ent. Soc. Phil., 5). As stated, Linné has no species under the name *Polyphemus* in his 10th or 12th Editions, or in the Mus. Lud. Ulr., but I find that in the 13th Edition, p. 2402, No. 461, he cites a species under that name. Linné gives references to Fabricius and to Cramer and undoubtedly intends our species. He says: "*Habitat in America boreali, Jamaica.*" The preceding species is his *Paphia*, of which he says: "*Habitat in Asia*," and there is no reference, doubtful or otherwise, to Catesby. So that I repeat my former conclusion that there can be no reasonable doubt that Linné's *Paphia* is a distinct species from our *Polyphemus*, and that we are not justified in surrendering the latter name. I have recently given the synonymy of the North American forms of the group (*Attaci*) to which Polyphemus belongs in the Transactions of the American Philosophical Society.—A. R. Grote.

Notes on Californian Thrushes.—The recent appearance of the excellent work by Baird, Brewer and Ridgway, on the "History of North American Birds," makes it necessary for me to explain some discrepancies between my statements in the "Ornithology of California" and the views taken by them in relation to the two common brown thrushes of California.

1. A reference to Baird's report, in Vol. IX, P.R.R. series, will show that the specimens collected on those expeditions led him to believe that *T. ustulatus* was limited to the "Coast region of Washington Territory and Oregon," while the *T. nanus* was confined to the "Pacific Slope, from Ft. Bridger and Ft. Crook (about lat. 41°) to the valley of the Gila and Cape St. Lucas.[1] In the Ornithology of California I merely extended the range of *ustulatus* to "San Francisco in winter," having observed it there (as I supposed) while in the Colorado valley, and at San Diego I only found *nanus* at that season. Relying too much on the authority of the Pacific Railroad Report, I assumed that *ustulatus* was a northern form only, and *nanus* a southern and consequently dwarfed race (without reference to their eastern allies). I may

[1] Townsend however obtained the type without doubt at Columbia River.

remark, that in the woods it is impossible to distinguish between them at the distance such shy birds usually keep from the observer.

2. At the time I wrote the Ornithology of California, I had collected only *nanus* in winter, and with the above mentioned impressions, too hastily concluded that they remained in the state all summer, while the *ustulatus* retired to more northern regions. Afterwards when collecting the nests and eggs assigned to *nanus*, it was inconvenient, and seemed unnecessary to preserve the birds also. I will admit therefore, that I may have described those of *ustulatus* as belonging to *nanus*.

3. That there is still reason to believe that *nanus* does not always build on the ground is shown by the note in Vol. III, Hist. N. A. Birds, p. 499, describing the nest of "var. *Audubonii*" on a tree, and in a region remarkable for dryness.[2]

4. The statement on page just quoted, that "Dr. Cooper has sent to the Smithsonian Institution skins of his *T. nanus* and they prove to be *T. ustulatus*," is not quite correct. I sent *one* skin from near San Buenaventura with notes showing its differences from *T. nanus* (which I also obtained there), and my uncertainty as to what to call it. Prof. Baird wrote that it was *T. ustulatus*, although I had supposed, from its very olivaceous hue, that it might be *Audubonii*. I had not considered it *nanus*, and it was so much less brown than the *ustulatus* I obtained in Washington Territory that I did not suppose it the same. It must be considered a link between them and the var. *Swainsonii*.

5. The facts now stand exactly in reverse of the range given in the Report on Birds in the Pacific Railroad Survey. Thus *ustulatus* is the *summer* species of California as well as northward, breeding from Alaska south to lat. 35°, near the coast and in low grounds. *Nanus* is the *winter* species of California, retiring north and perhaps to the high mountains in summer, while in winter it only reaches Cape St. Lucas, *ustulatus* going entirely south of the United States, and as far as Guatemala.

6. In southern Californian specimens there is not so marked a difference between the color of the tail and back in *ustulatus* and *nanus* as to distinguish them strongly without comparison, nor

[2] Audubon and Wilson also described the nest and eggs of var. *Swainsonii* much as I did those of var. *nanus*.

can I give any differences in song, unless I suppose that *nanus* is quite silent while with us, and that all my notes on songs belong only to *ustulatus*. They are easily distinguishable by measurements.

7. Admitting the determinations of the authors quoted, the law of priority requires us to call the species *T. ustulatus* and var. *Swainsonii*, also *T. nanus* and vars. *Pallasii* and *Audubonii*. It is however a question not decided by them, whether the two species of Peru are identical with those of North America. If found south of the equator, they must be supposed to migrate toward the south pole, if at all, and there may even be two or three races of each in South America, corresponding to longitudinal differences in climate. Though quoting Fauna Peruana they do not give localities for ours south of the equator. Do *T. minimus* Lafr. and *T. guttatus* Cab. cover the Peruvian species? or is any similar species found there?—J. G. Cooper.

Ascending Process of the Astragalus in Birds.[1]—Mr. Morse first described the ascending process of the astragalus in birds, as seen in the hen. The astragalus in birds coössifies early with the end of the tibia, and this process, as it has been called, ascends as a spur from the upper side of the astragalus in front of the tibia. In certain extinct reptiles, like Hypsilophodon, Lælaps, and others, the ascending process of the astragalus shows itself as an avian character.

A few years ago Prof. Wyman discovered that this process had an independent centre of ossification, and therefore could not be a process of the bone. Mr. Morse had interpreted this bone as the intermedium of Gegenbaur. The intermedium is a tarsal bone, occupying a position between the astragalus and calcaneum. In the Saurians, turtles, and other reptiles this bone is well seen. In certain amphibians as in the salamanders, the bone is long, wedge-shaped, and partially projects between the tibia and fibula.

Mr. Morse has expressed his belief that the ascending process of the astragalus represented the intermedium of reptiles. He had published in the "Annals of the New York Lyceum of Natural History" a theoretic figure of the proper position of this bone in birds, comparing it with the intermedium of certain salamanders.

[1] Abstract of a paper read at the Hartford meeting of the American Association for the Advancement of Science, by Edward S. Morse.

He explained its position in front of the tibia as a supposed process of the astragalus, by calling attention to the excessive tendency to anchylosis in birds. The widening of the tibia to include all the tarsals within its width necessarily brings the intermedium in front of the tibia, and, as it early unites with the astragalus, has naturally been mistaken.

Mr. Morse had been able to confirm his opinion regarding the nature of this bone in studying the embryos of the common tern at Penikese Island. In the embryo bird the intermedium appeared as a long oval bone between the astragalus and calcaneum, passing up between the tibia and fibula as seen in the lower reptiles.

In this connection it is interesting to observe that in the mammalia the intermedium does not occur, and Gegenbaur has expressed the opinion that the astragalus of mammals represents the astragalus and intermedium united. These investigations might possibly go to confirm that opinion in the fact that in reptiles the intermedium is separate; in birds it is separate in the young bird, but connected with the astragalus in the adult state, while in mammals, if Gegenbaur be right, it is always so connected.

GEOLOGY.

Return of Professor Marsh's Expedition.—Professor Marsh and party returned to New Haven, Dec. 12th, after an absence of two months in the West. The object of the present expedition was to examine a remarkable fossil locality, discovered during the past summer in the "Bad Lands" south of the Black Hills. The explorations were very successful, notwithstanding extremely cold weather, and the continued hostility of the Sioux Indians. The latter refused to allow the expedition to cross White River, but a reluctant consent was at last obtained. They afterward stopped the party on the way to the "Bad Lands," attempted a night attack on their camp, and otherwise molested them, but the accompanying escort of U. S. troops proved sufficient for protection. The fossil deposits explored were mainly of Miocene age, and although quite limited in extent, proved to be rich beyond expectation. Nearly two tons of fossil bones were collected, most of them rare specimens, and many unknown to science. Among the most interesting remains found were several species of gigantic *Brontotheridæ*, nearly as large as elephants. At one point these bones were

heaped together in such numbers as to indicate that the animals lived in herds, and had been washed into this ancient lake by a freshet. Successful explorations were made, also, in the Pliocene strata of the same region. All the collections secured go to Yale College, and will soon be described by Professor Marsh.

Summer School of Geology.—The great difficulty that all students of practical geology meet at the outset of their career is to obtain proper instruction in the methods of working in the field. With a view to meet this need the teachers of geology at Harvard University have determined, with the consent of its governing body, to begin a system of summer instruction intended for the proper geological training of persons having sufficient preliminary knowledge to pursue field studies with profit. The school will be established in a camp to be formed in the state of Kentucky, in the immediate neighborhood of Cumberland Gap. This place offers great advantages for the pursuit of such studies. In that neighborhood a section from the Potsdam sandstone to the middle carboniferous can be easily traced, and it is in the midst of the noble mountain structure of the Appalachians, and affords great advantages for the study of dynamic geology. At the same time the situation is entirely healthy, being elevated more than fifteen hundred feet above the sea, thus avoiding all malaria and the extreme heat of lower regions.

The instruction will include lectures on different subjects connected with geology, by a competent corps of instructors, and practice in field work. Opportunities will be thus afforded for the study of dynamic geology, paleontology, chemical geology, with something of zoology and botany.

Students will be required to pay in advance for the instruction and use of camp furniture, the fee of fifty dollars, and will also be required to pay weekly in advance the actual cost of their subsistence, which is expected not to exceed three dollars per week.

The first term will be continued for about ten weeks, or from July 1st to Sept. 1st, 1875. Transportation of students from the nearest railway stations in Kentucky and Tennessee will be provided at actual cost. An effort will be made to secure a reduction of fare to students travelling to and fro from the camp.

This school is meant especially for teachers of natural science, and those who are desirous of pursuing the study of geology in a

practical and efficient fashion, and it will therefore be limited to persons of some training fitting them for such work. The number will be limited to twenty-five, and the school will not be begun if there are less than ten applicants. Persons desirous of joining the school should apply to F. W. Harris, President's Secretary, Harvard University, Cambridge, Mass.—N. S. S.

Ancient Lake Basins of the Rocky Mountains.—The existence of several large fresh water lakes in the Rocky Mountain region, remarks Prof. Marsh (in the American Journal of Science and Arts, Jan., 1875), is now well established, mainly through the researches of explorers whom the striking scenery of the "Bad Lands," or the extinct animals entombed in them, have attracted thither. The oldest are of Eocene age. The one best known forms the Green River basin, and the sediments are at least 6,000 feet in thickness. The animal remains found in these strata are those of tapir-like mammals, monkeys, crocodiles, lizards and serpents, and betoken a tropical climate. The lake basin of the "Bad Lands" of Nebraska is of Miocene age, and the strata are about 300 feet thick. The assemblage of animals indicates a climate less tropical than that of the Eocene lakes, as seen in the absence of monkeys, and the scarcity of reptilian life. The Brontotheridæ, the largest known Miocene mammals, are peculiar to the lower strata of this basin. The late tertiary or Pliocene basin, Marsh calls the Niobrara basin; it extended from Nebraska nearly to the Gulf of Mexico. The strata are nearly or quite 1,500 feet thick. The fauna indicates a warm temperate climate, the more common animals being a mastodon, rhinoceroses, camels, and horses, the latter being especially abundant.

ANTHROPOLOGY.

Copper as a Preservative of Animal and Vegetable Substances.—In examining an old Indian burying ground at Harpswell, Maine, several pieces of leather and strips of nicely twisted grass fibres were found which were fastened together at the sides with a tough grass thread passing through at intervals about an inch, though some of them were woven together. With these were embedded several copper tubes, and some thin sheets of copper; the corroding of the latter so impregnated the former that they

were in a good state of preservation; the pieces exhibiting the best marked effect of the copper were the strongest. The articles of which these pieces once formed a part had long since gone to decay; not coming in contact with the copper they were not spared to become articles of curiosity or of study to the ethnologist.—E. PALMER.

MICROSCOPY.

ROSS' NEW MICROSCOPES.—The adoption by this great house of the Jackson model of stand (which has long been very generally preferred in this country if not everywhere), in place of the transverse bar model which had come to be familiarly known as the Ross style, is an innovation of sufficient importance to attract special notice, and, we may add, congratulation. The magnificent workmanship of the old Ross stand is no secret and is a sufficient assurance of the mechanical excellence of the new ones, while the fact that they are designed by Mr. Wenham leaves nothing to be said as to their microscopical efficiency. The new stands, while adhering substantially to the Jackson model, combine some of the best features of the previous stands of Ross, Powell & Lealand, Ladd, and other makers.

The Ross' new patent object-glasses (devised by Mr. Wenham) are believed by the makers to have so well proved their superiority that they are now exclusively offered, and the old construction abandoned, from the $\frac{1}{2}$ inch upwards.

VERY THIN COVERING GLASS.—Mr. G. J. Burch, of the Queckett Club, recommends the following procedure for producing very thin covers, not for general use, but only when excessive thinness is required. Seal up the end of a $\frac{1}{4}$ inch glass tube in a blowpipe flame, and continue to heat it until so soft as to require turning to prevent its falling out of shape; then remove it from the flame and blow into it strongly until it swells, at first slowly and then suddenly, into a very thin bubble of glass, of perhaps four inches diameter. When cold it is to be broken in pieces, and the pieces cut to shape with a writing diamond. When perfect flatness is required, lay a piece on a flat strip of platinum foil and place it for a moment in a Bunsen flame, which, at a red heat, will both flatten and anneal it. A piece of this glass measured $\frac{1}{2500}$ inch $=$·0004 inch, while Dr. Pigott's measurement of the thinnest glass in his possession was ·0022, which is $5\frac{1}{2}$ times as thick.

FALSE-LIGHT EXCLUDER FOR OBJECTIVES.—Mr. Wenham's experiments upon the aperture of objectives, cutting off stray light by a perforated stop surrounding the focal plane of the objective, have suggested to Mr. Ingpen the usefulness of a similar contrivance for cutting off false light in objectives in actual use, and thereby preventing that milkiness of field which mars some otherwise excellent objectives. He slips over the objective a cap having a perforation a little larger than the field of the objective. When this cap is slipped down to the cover-glass, the full aperture of the lens is used and stray light excluded. The cap, by slipping it up toward or to the objective, may be made useful to secure a variety of reduced apertures. Such a contrivance which has hitherto been used in connection with micro-spectroscopic work is evidently capable of a more extended usefulness.

STAINING VEGETABLE TISSUES.—Persons unaccustomed to microscopical manipulation suffer much loss of time in working from such superb books as those of Beale and Frey, partly in selecting from the great wealth of material and partly from the necessary omission of minute details in the way of working directions. Of staining solutions, for instance, the beginner is at a loss to choose from the pages of excellent formulas, and is not unlikely to begin with the least suitable one; and, partly for this reason, few beginners are aware of the ease with which the modern methods of staining may be employed, or of the exquisite results attainable. Such will be glad to use the following hints, which are mainly abstracted from a paper by Dr. Christopher Johnston in the "Monthly Microscopical Journal."

For staining animal tissue carmine succeeds perfectly, and logwood gives also beautiful results, but aniline is unsatisfactory; while for vegetable work logwood-violet and aniline-blue are preferred to carmine, being easier to work and pleasanter to study, especially by lamplight.

Logwood staining was introduced by Boehmer, who used solutions of hæmatoxylin and alum, mixing them in small quantities when needed for use. Dr. Frey simplified the plan by mixing logwood and alum solutions until a violet color was produced, filtering the solution thus prepared, and keeping it for use when required. Dr. Arnold's plan, which is the most convenient, is to pulverize one part of extract of logwood and three parts of alum in a mortar,

and gradually add water so as to form a saturated solution, some of the powder being left undissolved. When filtered this should be of a dark violet color; if a dirty red, add more alum. After standing a few days add one-fourth of its bulk of 75 per cent. alcohol. Should a scum form on the surface, add a few drops of alcohol and filter.

Ordinary aniline blue is insoluble in water, but made soluble by the addition of sulphuric acid; but it may now be obtained in soluble form at the color shops, and a one per cent. aqueous solutiin of the soluble blue, with the addition of a little alcohol and a trace of oxalic or acetic acid may be used, or the solution sold as "Bower's Blue Ink," may be slightly acidulated and used instead.

The specimen, whether a section or a thin leaf, if it has not been blanched by previous maceration in alcohol, is decolorized by soaking in Labarraque's solution of chlorinated soda until perfectly achromatic and transparent, and then soaked in distilled water for an hour or two. It is next soaked in a three per cent. aqueous solution of alum, then in the logwood solution (diluted with twenty-five per cent. alcohol if a slight or slow effect is desired); when sufficiently stained it is washed in the alum solution, and then transferred through alcohol and oil of cloves, to damar varnish or a chloroformic solution of balsam. Or else the bleached and washed specimen is soaked in a three per cent. solution of oxalic acid in fifty per cent. alcohol, then in the blue fluid until intensely colored, washed in ninety per cent. alcohol to remove the superfluous aniline, and transferred promptly through absolute alcohol and oil of cloves to damar or the balsam solution. A small weight is placed upon the cover, and a temporary label on the slide while the balsam hardens.

The logwood stainings may be mounted at leisure and at any time, but those of aniline must be completed at once or the color will wash out.

A Method of Preparing and Mounting Suitable Insects for Microscopical Examination.[1]—After procuring the insect, place it under a tumbler or suitable vessel with a few drops of ether; when dead, wet it with alcohol, and place it in liquor potassæ of the strength of 1 oz. (troy) fused caustic potassa and 1 pint distilled water.

[1] Read before the Memphis Microscopical Society, December 17, 1874.

Let it soak in this liquid until the skin or external part is soft, and the internal substance in such a condition that, upon slight pressure, the insect can be evacuated by the natural, or, if necessary, an artificial opening. This is best done under water, and a white plate is best to use.

When this is effected the object is to be cleaned. Have a camel's hair brush in each hand; with one hold the object, and with the other brush every part of the insect, and on both sides; float it on a glass slide, and dispose each part in a natural position, either creeping or flying.

Cover this slip with another glass slip of the same size, and press gently together, using only sufficient force to make it as thin as possible without crushing or destroying it.

Confine these two glasses, the insect being between, with a fine brass wire as a string, and place it in clean water, to remain twenty-four or thirty-six hours; this will give the insect a position which is not easily changed, and it is therefore proper that the position be such as you desire when finished. Remove the string, and open the glasses carefully under water, and float the insect off; give it another brushing, and let it remain a few hours to remove the potassa.

Transfer to a small but suitable vessel containing the strongest alcohol that can be obtained, pursuing the same course as with the water, placing between glass slips, tied together, and letting it remain about twenty-four hours.

Transfer to a vessel containing spirits of turpentine. It is to remain in this, kept between the glasses, until all the water is removed. While in the turpentine, the insect is to be released several times and the moisture removed from the glasses, and the insect again confined.

When no moisture is visible surrounding the insect, heat the glass slips containing the insect over a spirit lamp until the contained turpentine nearly boils, when if any moisture be present, it will show its presence when the glasses are cold.

If free from moisture it is ready for mounting: float it on a suitable slide from the turpentine; drop a sufficient quantity of balsam upon it; examine, and if no foreign substances are present, heat the cover slightly, and apply in the usual way.

After a day or two, heat the slide moderately, and press out the surplus balsam, and place a small weight upon the cover while drying.

After the lapse of a suitable time, remove the surplus and clean the slide.

In all the operations the utmost cleanliness is to be observed; the liquids used to be frequently filtered and kept from dust, and a large share of patience will be found necessary.—THOMAS W. STARR, 324 *Chestnut St., Philadelphia.*

DISTINGUISHING BLOOD CORPUSCLES.—The ordinary method of soaking out the shrivelled and distorted cells from a dried blood stain or clot, and then measuring their diameter under a suitably high power, is conceded to be satisfactory in many of the most frequently occurring cases (for instance, Dr. J. G. Richardson, who has been for several years a prominent advocate of the reliability of this method of distinguishing human blood, under high powers from that of certain domestic animals, has recently shown by numerous experiments the feasibility of thus distinguishing the blood of man, ox and sheep); but it fails when the corpuscles approach each other too nearly in size. It also gives unsatisfactory results with the oval nucleated corpuscles of reptiles, etc., which, when swelled by soaking, do not arrive at their original condition. Dr. R. M. Bertolet of the Philadelphia Hospital is represented as advising the following method of staining these corpuscles, which is applying one of the chemical tests for blood in a new way and with great precision. The blood is moistened with slightly acidulated glycerine, and then carefully irrigated with an alcoholic solution of guiacum resin, and finally a small quantity of ethereal solution of ozonic ether (peroxide of hydrogen) is flowed beneath the cover. By this procedure the whole corpuscle is stained of a uniform color which varies in different corpuscles from a light sapphire to a deep blue, except in case of the nucleated corpuscles in which the nucleus assumes a distinctly different tint from the rest.

EMBEDDING TISSUES.—Mr. R. Packenham Williams, in a paper "On Cutting Sections of the Eye of Insects," read before the Queckett Club, advises that the head, after hardening in alcohol, should be embedded in a mixture of butter of cocoa, bleached beeswax, and a little new Canada balsam. This mixture melts at about 120°, and may be removed from the sections, after cutting, by gently warming them in turpentine. The cutter used in connection with this compound should be wetted with turpentine while making the sections.

SPHÆRAPHIDES. — Professor George Gulliver calls attention in the "Monthly Microscopical Journal," to the hitherto unnoticed sphæraphides in *Leonurus cardiaca*, and also to the two kinds of sphæraphides occurring in this species as well as in *Urtica divica*, *U. ureus*, *Parietaria diffusa* and *Humulus lupulus:* one kind, the larger and smoother, occurring in the blades of the leaves and consisting chiefly of carbonate of lime; the other kind, smaller and more roughened on the surface, occurring in the fibro-vascular bundles of the leaf and in the pith, and consisting of oxalate of lime except in *L. cardiaca* in which they are composed chiefly of carbonate of lime and in which they are wanting in the pith. Boiling the parts in caustic potash solution discloses these crystals admirably even when not otherwise easily found, as in the case of the leaf of *Ficus carica*.

SPIDERS' WEB.—Mr. H. J. M. Underhill publishes in "Science Gossip" an interesting microscopical study of the spider's web and the mechanism by which it is produced. He finds that of the two to four pairs of spinnerets or web-forming papillæ possessed by spiders, the British species have at least three pairs. The first, or upper pair of spinnerets, produce plain threads of the largest size which are stretched taut from point to point to form the foundation of the web, especially at the edges where great strength is essential; these threads are often doubled or trebled for greater security. The spinnerets of the second pair are somewhat similar but smaller, and produce a smaller but otherwise similar thread. The third pair differs notably in structure, and produces a thread which is either elastic and studded with viscid globules, or is slack, irregular and curled, being in either case adapted for entangling and holding the insect prey. In the common house spider (*Tegenaria domestica*) there are about three hundred and sixty silk-glands each furnished with a separate duct and terminating in a silk tube at the extremity of a spinneret. The first pair of spinnerets has about sixty of these glands, the second pair eighty, and the third pair two hundred and twenty, which are more complicated in structure, though much smaller than the others. In spiders which have four pairs of spinnerets the thread of the fourth pair is somewhat like that of the second, and the aggregate number of silk tubes is greatly increased, being in *Ciniflo atrox* about twenty-six hun-

dred. Thus each pair of spinnerets is calculated to produce a different kind or size of thread; contrary to the common belief that each thread is formed by a coalescence of silk from all, in which case the change from viscid to plain thread would depend in some obscure manner on the will of the animal. Nor do those drops of silk which are simultaneously produced coalesce into a homogeneous thread, as a web under a high power will show many of the threads frayed like a worn rope, and an unfortunate fly is not bound by the coils of a single thread but by a broad band of many detached threads, from the tips of the six spinnerets arranged in a line, thrown rapidly around it.

Coarse Lines on Diatoms.—Mr. F. Kitton, the valued correspondent of "Science-Gossip," again calls attention to the fact that while "smooth" diatoms have been patiently studied with lenses of high resolving power, those with coarse lines or costæ being easy of resolution have escaped such scrutiny, though many of them are possessed of finer markings which are capable of resolution by the means applied to more "difficult" diatoms. The costæ of some species of Synedra and Cymbella he has recently studied in this way, and found the rib-like lines composed of a series of beads, reminding him of peas in a well filled pod. He has not yet been similarly successful with the Pinnularias.

NOTES.

The State Board of Education have presented to the Massachusetts Legislature an extended report relating to the proposed general survey of the state, a subject which was referred to the Board for report by the last legislature. This report makes prominent a number of important points bearing on the necessity of the proposed survey, and gives minute estimates of its cost, which are placed at the comparatively insignificant sum of $25,000 a year for a period of fifteen years. The value of the survey to the people of the state is so very apparent that we have little fear but that the legislature will pass the bill, as soon as it comes before them, notwithstanding the economical wave that in its periodic course has again broken upon our land. Certainly, if we were blessed with a more thorough understanding of our resource, and worked in all departments with more knowledge of the laws of

nature, and did not so ignorantly interfere with laws which we cannot change, we should not so often be in that sad position, when we have to stop and ask, Why are we so poor when riches are under our feet? To this end, that we may know our resources, and not only take better advantage of them, but also through knowledge avoid mistakes, we hold that the thorough survey of the state will prove of lasting benefit, and long before it is finally completed show itself even a financial success.

The survey, as asked for by the original memorial of the American Academy and as endorsed by the State Board of education, is not designed to be simply topographical and geological, though the well known imperfections of all maps of the state show the importance of the former, while the almost total ignorance of our very peculiar geology, and the present excitement at Newburyport, over the discovery of lead and silver, certainly are proof of the importance of the latter topic. But not only are these departments contemplated, but that of biology as well, and here again can we cite the importance of the survey in a field where ignorance is so uniformly the rule that to be wise is considered foolish. Here are thousands of people in the state dependent on the success of their crops and their stock for support, and hundreds of thousands still more dependent on what their farms will bring them, and all, so nearly or entirely ignorant of nature's laws, that hardly an act is committed in the efforts of cultivation, that is not sowing the seeds of failure in the future. It is the bearing which the biological part of the survey will have on these practical and vital points of our daily life, that will in the end make it the most important branch of the survey, though the very ignorance which will be its work to supplant by knowledge, will be the cause of its being the least understood at first, and the hardest to make men realize the importance of providing for, by Legislation.

For our credit as a state ever ready to do that which is best for the people, and from the much higher principle, the advancement of knowledge among men, and the consequent higher degree of general education, we hope and trust that the important matter of a thorough and exhaustive survey in all departments, will not only be provided for by the present Legislature, but will be placed on so firm a basis that no matter what political revolutions may ensue during the next fifteen years, the provisions for the survey shall remain intact.

Three preliminary maps have during the past year been published by Hayden's U. S. Geological Survey of the Territories, the one of most interest being a preliminary map of Central Colorado showing the region surveyed in 1873.

A glance at the "Catalogue of the Publications of the U. S. Geological Survey of the Territories, F. V. Hayden, Geologist in charge, Washington, 1874," may give some idea of the energy shown in the conduct of this survey; several volumes appearing annually, beside smaller pamphlets, containing a large mass of information regarding the public lands. Exchanges of the publications of the survey with societies and individuals engaged in scientific studies are desired.

Prof. Ch. Fred. Hartt, who left this country for Brazil by way of England in Oct. last with his assistant and photographer, Mr. John Branner of the Geological Laboratory, Cornell University, was busy on the surface geology of the neighborhood of Rio de Janeiro when last heard from. We believe he has found reasons to differ from Prof. T. Sterry Hunt's views in regard to the origin of the loose materials covering the rocks around Rio. He has been going over the ground with great care, working it up in detail, and we shall expect an interesting communication from him on the subject as soon as he returns.

Sir William Jardine died Nov. 12 at the age of seventy-four. Though especially devoted to ornithology, he established the "Magazine of Zoology and Botany," afterwards the "Annals of Natural History," which in 1841 was combined with the Magazine of Natural History to form the "Annals and Magazine of Natural History," now the leading English journal in this department of science.

Valuable sets of Floridan plants have been made by Dr. G. Palmer, and are authentically named and for sale at the herbarium of the Botanic Garden at Cambridge. They can be purchased on application to Prof. A. Gray, as Dr. P. is now in California.

Mr. F. W. Putnam has received the appointment of Curator of the Peabody Museum of American Archæology and Ethnology at Cambridge, held by the late Professor Wyman.

The Governor of Rhode Island has recommended, in his inaugural address, a geological survey of that state.